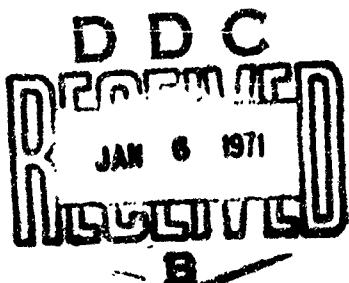


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AFOSR 70-2368TR

CONFERENCE ON RESEARCH
TO EXPAND THE USEFULNESS OF
THE MILITARY WORKING DOG



AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Air Force Systems Command, USAF

November 1970

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ABSTRACT

Proceedings of the first working conference on scientific research related to problems and potentials of the military dog program operated by the U.S. Air Force. Aspects of dog procurement, training and medical problems pose research questions. Current investigations of animal physiology, psychology, and olfaction are examples of potentials for developing new techniques and roles in military dog training and use.

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CONFERENCE ON RESEARCH
TO EXPAND THE USEFULNESS OF
THE MILITARY WORKING DOG

Papers presented at the Conference
Wilford Hall USAF Medical Center
Lackland AFB, Texas, 18-20 March 1970

Air Force Office of Scientific Research
Air Force Systems Command, USAF

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FOREWORD

Expanding the usefulness of the military working dog is directly related to expanding the usefulness of the military policeman. The highly trained patrol dog is the most effective, readily available and economical weapon system available to him.

This concept accounts for the more than 10,000 dogs in service worldwide with the Department of Defense. The Air Force is the sole procuring agency for DOD for military dogs, which are replaced at the rate of about 2,000 each year. The source of these dogs, nearly all German Shepherds, is the general public, either by donation or by sale, and the supply is barely sufficient to meet the services' growing needs.

The German Shepherd has been found to be the most suitable dog because of his singular willingness to work for the sole reward of a most intangible nature -- the approving pat and word of his handler, and for his outstanding physical characteristics of speed, stamina, strength and courage. The dog's sense of smell far surpasses that of humans, and dogs commonly detect persons as far as 500 yards upwind. The dog's hearing is thought to be about 20 times keener than man's. These characteristics combine to greatly multiply the effectiveness of an individual in such tasks as area security, tracking, search, narcotics detection, and other specialized jobs. Because these animals are so highly useful both within the military and elsewhere, there are promising opportunities for research to aid in the selection and training processes, and to extend the capabilities of working dogs in as yet untried ways.

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This first research conference held by the Air Force on the military dog was organized by Lt Col Charles E. Fuller, VC, of the Air Force Office of Scientific Research, and by Maj Roland C. Olson VC, of the Military Dog Veterinary Service at Lackland AFB. Its objective was to closely associate researchers with Air Force veterinarians and other representatives of those commands responsible for procuring, training and using dogs. The papers contained in this volume indicate some of the needs, problems, objectives, and research potentials under discussion and consideration.

The AFOSR research program includes such projects as neuromuscular investigations of canine hip dysplasia, a condition which accounts for 80 percent of all medical rejections of dogs offered to the military; investigations of dog psychology and training; and animal physiology, together with telemetry techniques for imparting commands or other stimuli in the field.

Attending the conference were staff veterinarians of major dog-using commands of the Air Force, including SAC, AFLC, ATC, and AFSC.

AFOSR wishes to thank the commanders and personnel of all the organizations represented for their outstanding cooperation and support of the conference, and for their confidence in the long range benefits of research for the military dog program.

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INTRODUCTORY REMARKS

Lt Col Charles E. Fuller, USAF, VC
AFOSR Directorate of Life Sciences

Welcome to the first USAF Conference on Research to Expand the Usefulness of the Military Working Dog. The Air Force Office of Scientific Research is pleased to join the Military Working Dog Veterinary Medical Facility of the Wilford Hall Hospital in sponsoring this working conference. Major Roland C. Olson, USAF, VC, Officer in Charge of the Veterinary Medical Facility at the Center, and his staff, have been responsible for local arrangements and support. I want to express my appreciation to Dr. Olson and his people for all their efforts in behalf of the Air Force organizations and institutions represented here. This conference brings together representatives of the Air Force Air Training Command (ATC), Air Force Logistics Command (AFLC), Air Force Systems Command (AFSC), the Air Force Security Police, the Air Force Office of Scientific Research (AFOSR), and the Office of Aerospace Research (OAR), with several scientists who are conducting AFOSR-supported research contributing to the Military Working Dog program. By working together, discussing problems, capabilities and ideas, and seeing the working elements and people of this complex program of Military Working Dog procurement, we hope to create new and open channels of communication and a realistic understanding by the research scientists here of problems faced by the Air Force. We also hope that Air Force representatives here will better understand the capabilities, goals and objectives of the research scientists. I am sorry that Colonel Thomas Murnane of the U.S. Army Medical R&D Command, and Colonel M.W. Castleberry, Chief, Department of Biosensor Research, WRAIR, could not join us here today because of other commitments. By having a question and discussion period after each presentation, I know that an atmosphere of informality and productive inquiry will prevail.

I think it very appropriate to point out that Air Force basic research directly addresses problems encountered by military use of the dog. To the best of my knowledge, research by which the dog might be improved is a comparatively recent development.

In its investigations designed to extend the usefulness of the military dog, AFOSR has assigned a support priority based upon close, frequent and informal relationships with Air Force organi-

zations and people responsible for the military dog program. In other words, you might say we are seeking to provide answers for questions which haven't officially been asked. In order to properly continue to provide research assistance for the military dog, people speaking a common language and addressing similar goals must identify problem areas. They must make their research needs known to their headquarters and they must assist in the validation of a Headquarters research requirement, or face a status quo continued existence. Research support capability which can aid in the solution of physical and behavioral problems, or improving the usefulness of the military working dog, rests within the resources of the USAF School of Aerospace Medicine, the Aerospace Medical Research Laboratories, other selected research units of the Air Force Systems Command which are responsible to the Aerospace Medical Division, and the Air Force Office of Scientific Research, which provides for research support in the university community, non- and not-for-profit organizations, and industry. It is essential for all of us here, and many who aren't here, to act together, to communicate freely, and to establish research requirements which will encourage research and development efforts. Colonel William Hayman, Chief of Veterinary Services of Lackland AFB, will serve as moderator the first day, and Dr. Harvey Savelly, Director of Life Sciences, AFOSR, will serve as moderator for the second day.

I. Operational Aspects of
the Military Working Dog Program

RECRUITMENT AND PROCUREMENT

Mr. Bo Kilburn
Military Working Dog Program Manager
AFLC
HQ SAAMA
Kelly AFB, Texas

Gentlemen, the purpose of my talk is to acquaint you with some of the significant aspects of the Military Working Dog Program. This program actually has a dual function or mission. One aspect consists of recruitment and procurement of dogs; the other involves logistics, which includes receipt and distribution, kenneling, feeding, care, and welfare.

We naturally have our problems and would welcome any advice or assistance from the scientific community, specifically the Office of Scientific Research. Many of the discussion topics and papers to be presented at this conference will be of particular interest to all of us in the Military Working Dog Program.

We have a unique and a most significant Air Force project. From a logistical standpoint, we are involved with a commodity that is somewhere between a personnel and hardware system. Dogs are not nuts and bolts; they are animate beings that must be fed and kept healthy. The requirements for dogs are tied to personnel requirements, meaning when there is a requirement change in handler personnel, dog requirements are likewise changed. In other words, it is impossible to establish a long range requirement or procurement schedule.

How do we get our dogs? What type recruitment program do we have? We get or recruit dogs from the John Q. Public - individual owners throughout the United States who desire to sell or donate their dogs to

the U. S. Government. There are many dog owners who must get rid of their dogs -- maybe it bites the mailman or a neighbor's child; too big for Junior, or expensive to feed -- no yard, or for some other equally urgent reason to give up a pet.

The part of the recruitment program involving advertising and publicity is largely handled by the USAF Recruiting Service. Through a Host-Tenant Support Agreement, the Recruiting Service provides the Military Working Dog Program with paid advertising and publicity throughout the country. This is the media we use to inform the general public or otherwise make known our need for dogs.

Individual dog owners, who may have a dog to sell or donate, get in touch with our center by mail or telephone and from this initial contact, the negotiation and acquisition process is set in motion. They may have read in the newspaper, heard over the radio or seen on TV where German Shepherd Dogs are needed by the Armed Forces.

The procurement process that follows is known as our mail-back or inquiry method. After it has been established that a person has a dog meeting the required specification, they are sent appropriate documents or proposal and veterinary examination forms to be completed and returned to the center for evaluation.

When our veterinarians and processing personnel are satisfied that the dog meets the minimum qualifications, from the data submitted by mail, the owner is notified that a crate will be shipped to him at government expense, and that they should ship their dog to the Center at Lackland AFB for final testing and evaluation before acceptance and/or rejection.

The normal processing time at the Center is 21 days. At least fifty percent of dogs are rejected, including paperwork turn-downs and actual temperament and medical rejects. The majority of medical rejects are for hip dysplasia which we hope to hear more about during this conference. Major Olson will cover the details on medical rejections in his presentation. Captain Sullivan will discuss temperament rejections and testing procedures.

Our other method of procurement is through mobile dog buy teams. In other words, when we need to augment our normal mail-back procurement rate, we set up a dog buy or procurement trip to a pre-selected metropolitan area in the United States. Wherever possible, the team will set up their testing station at a military installation. Advertising and publicity are arranged so the public will know when and where the mobile team will be testing dogs in their area.

Our number "1" recruiter is our War Hero - NEMO. Capt. Sullivan, his master, travels with NEMO throughout the country in behalf of the Military Dog Procurement Program. Millions of dollars of free advertising and hundreds of dogs have been procured as a result of the TV, Radio, and newspaper coverage given NEMO - the hero and recruiter of German Shepherd dogs for the Armed Services. The mobile procurement team recruits, receives, processes, and buys dogs in the field. If accepted, the owner is paid for his dog on-the-spot.

Our procurement team consists of from 9 to 14 military team members. The team makeup includes a veterinarian, veterinary technicians, testers, dog handlers, and other support type personnel. The team normally

operates over a weekend, or at most a 3 to 4 day trip at any one location. The average number of dogs accepted or procured per trip is from 30 to 40.

The minimum specifications or qualifications for acceptable German Shepherds is that they be 1-3 years of age, weigh 60 pounds and be 23 inches at the shoulder, not be pure white, and females are acceptable if spayed.

People become very emotional over their dogs. Not only do they ask many questions during buy trips, but we receive many letters from Peace-Niks, Dog Lovers, Congressional inquiries, and yes a letter from a little girl to her dog in the service. I have several of these with me today to further pinpoint the type letters we receive.

We pay up to \$150.00 for acceptable dogs. We have problems involving people who allegedly accuse others of stealing their dog. We do have a few "pen-hookers" who buy and sell dogs to the government, however when it comes to proof that a dog is stolen, the matter is not only complex but viturally impossible. We do not require proof of ownership beyond the owner signing the documents which require owner's signature. We assume that any person who signs a government document and receives Uncle Sam's money for a purchased dog, is doing so in good faith. If it can be proven that he may be selling stolen dogs, this then becomes a matter for law enforcement.

As previously stated, owners are required to complete the proper documents and have their dog examined by a qualified veterinarian. They can take their dog to a military veterinarian for a free examination prior to shipment to the Dog Center, or to a civilian veterinarian of

their choice. At present, civilian veterinarians charge the owner their standard fee for conducting the required examination. The completed examination forms are returned to the Center by the veterinarian. We are in the process of establishing a system to reimburse or pay a civilian veterinarian for services performed in behalf of the Military Working Dog Program. In other words, the civilian veterinarian will be permitted to submit his bill for payment by the government. This procedure will save the government hundreds of dollars each year in transportation costs alone, since most of the hip dysplasia rejects can be determined by the veterinarian in the field or at the source. It is not difficult to understand the savings involved since over 30 percent of German Shepherds are subject to rejection for hip dysplasia, and we look at or examine some 3 to 4 thousand shepherds per year to insure we meet a requirement of from 1,500 to 2,000 new dogs on a year-to-year basis.

In reference to disposition of dogs which have been rejected at the Center, we have several methods. Most rejects are returned to the owner. We prefer this method and advise the owner accordingly. However, should the owner not be in a position where he could accept return of his rejected dog, he then must give the government all rights, titles, etc. to dispose of his rejected dog as it sees fit. This determination is made at the time he completes his proposal form offering his dog for sale or donation to the government.

Rejected dogs not returned to their owners are given away, either to individuals, or in some cases, to medical research. Several institutions

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which comply with the Laboratory Animal Welfare Act are recipients of some of these rejected dogs.

In reference to our procurement effort, we buy dogs to satisfy requirements of our Armed Forces or DoD Agencies on a worldwide basis. Sentry and Patrol dogs are trained at Lackland Air Force Base, Okinawa and Wiesbaden, Germany. Scout, Mine and Tunnel dogs are trained at Fort Benning, Georgia. Army Tracker and Dope Detector dogs are trained at Fort Gordon, Georgia. We buy Labrador Retrievers for the Army Tracker Program at Fort Gordon.

From a logistics standpoint, all dogs are maintained in a pool at our Center on Lackland. They are AFLC assets until transferred or shipped to one of the using agencies. When a shipment is made against a requisition, the accountability is transferred, and in the case of other services, they reimburse SAAMA (Air Force) for the cost of the dog. Excess dogs from the field are returned to the Center where they are again picked up as SAAMA assets and placed in trained dog pool for subsequent redistribution.

In summary, the Military Working Dog Center recruits, receives, processes, procures, kennels, feeds, cares for, ships, and disposes of military working dogs. In these processes, our military veterinarians and their technicians are indispensable. We all must work closely together to accomplish this unique and complex mission. Management, Detachment 37, and the Veterinary Service, which you will hear from today, continually work to improve the dog program. We are always looking for ways to improve our evaluation or testing procedures, both

from a temperament and medical standpoint. We hope this group and the scientific community in general, can point up new approaches on how we may be able to improve, not only the product (DOG), but methodology and techniques we may be able to use in our testing procedures, which will result in a better dog at less expense to the Government.

- Q. What is the average figure that it costs to bring an average dog in, food and personnel included?
- A. Maximum current going price for a raw German Shepherd dog is \$150; we get some for much less-some for anywhere from \$1 to \$50 to \$75 and \$100, and many donates. The average cost is about \$125 per dog. Procurement and veterinary costs, Detachment figures are about \$4.50 a day to maintain a dog. The program we have now is a million dollar-a-year program to meet the current program requirements. By the time you get a trained dog and have him out in the field, you have about \$2,500 in a dog.
- Q. Over the past couple of years, how many dogs did you not only procure but how many dogs did you ship out?
- A. In FY 69 we will produce or ship out 2,072 dogs, now 923 of these dogs are what we call untrained. They are going to PACAF, ARPAC for the Army Training Program, the Military Systems Program, other specialized programs in Korea; matter of fact the Army has an Army Sentry Dog semi-trained unit over there and then we have of course the Scout dogs both for the Marines and Army.
- Q. Do you procure adequate satisfactory numbers of dogs at the present time?
- A. Yes. We do have problems since we have specific specifications these dogs have to meet, but we have been able to keep a satisfactory number.
- Q. What is the average life expectancy of your dogs in the various programs you have?
- A. If we get a dog 3 years of age, we hope to get 6 years out of him. This means 9 years as an arbitrary cut off on a working dog. This doesn't mean an automatic euthanization at the end of 9 years, but the user starts programming a replacement for this dog at about that age.
- Q. You have a dog in SEA in the field, his life expectancy certainly isn't 6 years is it?
- A. No. Generally about 3 years is the maximum according to the experts in the combat zones.
- Q. Are dogs procured in Europe by you?
- A. We will start procuring dogs in Europe I would say within the next fiscal year. The reason for this is the DoD regulation coming up that mentions Lackland as the sole procurement agency. They have been procuring their own dogs up til now.

UNITED STATES AIR FORCE MILITARY DOG TRAINING

MSgt Gene McKathron
Patrol Dog Training Branch
3275th Technical School
Lackland AFB, Texas (ATC)

In World War I, the United States had no dog program. However, we used dogs obtained from the Belgians and French. Experience during the first world war established the need and value of dog utilization and resulted in the establishment of the K-9 Corps by the United States Army in May 1942. An estimated 250,000 dogs were used by all powers for mine detection, casualty, messenger, scout and sentry duty.

Two dogs in particular have been cited for outstanding accomplishment: Scout Dog York led 148 combat patrols in Korea without the loss of a single man due to enemy fire. Sentry Dog Nemo was officially retired as a result of his accomplishment in December 1966, when he alerted his handler to the presence of an infiltrating enemy force, thereby preventing an attack on Tan Son Nhut Air Base, Vietnam.

In 1958 the Air Force established the sentry dog school at Lackland Military Training Center.

Sentry Dog Training

The sentry dog training course is an eight week course with five measurable areas: 2 weeks of obedience, 4 weeks of agitation, detection and attack, and 2 weeks of night patrol training.

The sentry dog receives two weeks of basic obedience, which is designed to produce a reliable, obedient and responsive dog. He is taught five basic commands: Heel, Sit, Down, Stay, Come and will respond to either a verbal

or gesture command.

Agitation training is designed to develop the aggressiveness of a dog. Prior to any agitation or attack, a leather collar is placed on the dog, resulting in the dog's association of the collar with being agitated. Five types of agitation are used in training: individual or stake, line, column follow, circle and muzzle.

The secondary function of a sentry dog is to attack and apprehend. During the four weeks of field training, he is taught to pursue, attack, guard, reattack and escort. After releasing his dog to attack, a sentry dog handler goes to the dog, secures the leash, then controls the decoy. Having secured the leash, a sentry dog handler commands the dog to release by giving the command "out." If the dog does not release he is choked out.

Patrol Dog Training

The war in Southeast Asia has presented an entirely new set of problems in the concept of base defense. In Vietnam the sentry dog has little or no psychological deterrent and when detected the enemy seldom hesitates to engage the security force. It was recognized that new skills would have to be developed in order to make the dog more flexible. What was needed was a dog that could:

- (1) Detect the presence of the enemy, alert his handler and withdraw (undetected) at the option of the handler.
- (2) One that could be employed as a member of a security force by tracking or scouting in pursuit situations.

(3) One that could act as a member of a patrol or ambush without being distracted or agitated by the closeness of the other members of the patrol.

In 1967, assistance was obtained from the Washington, DC Metropolitan Police Dept. The best qualities of the civilian police dog were added to the best qualities of the military sentry dog. The result was the current Air Force patrol dog.

Originally, 30 patrol dog/handlers were trained and assigned to Castle, Davis Monthan and Vandenberg Air Force Bases for a 120 day field evaluation. They proved very effective. In August 1969, the Air Force ceased training of sentry dogs for Air Force use and began training patrol dogs.

The patrol dog course is a 12 week course with 8 measurable areas: obedience, agitation, attack, stand off, detection, tracking, building search and vehicle patrol.

Obedience: The patrol dog receives obedience training in three phases: basic, intermediate and advanced. The basic includes Heel, Sit, Down, Stay, Recall, and Military Drill. The intermediate consists primarily of teaching the dog to be obedient while the handler is at the end of the 360 inch leash, an' performance on the obstacle or confidence course. The advanced is off leash. This is designed to gain the control needed by a patrol dog team in preparation for advancing to the more specialized phases of field training.

Controlled aggression: This consists of training in agitation, attack, search, reattack, escort and stand off. Agitation training is begun by teasing a dog with a rag until he will bite and hold on to it. After the dog shows a degree of aggression toward the rag and the person using it, the agitator loosely wraps his arm with the same material and the dog is allowed to bite the arm. By allowing the dog to chase the agitator and not allowing him to bite every time the dog's desire to pursue and attack is built up.

Stand off: The dog is taught to release his bite and/or cease his attack. This exercise is called "stand off." On hearing this command when in pursuit of an individual, the dog must return to the handler without having attacked the agitator. If more than one person is being pursued by the dog and one of these persons surrender then the dog has been taught to pass that person by and continue to pursue the one that is escaping.

Search: The dog is placed in the sit-stay position while the handler searches a person who is about 15 feet away. The dog is not to break this position unless while the handler is conducting the search the person being searched attempts to harm the handler. If this occurs, the dog has been taught to re-attack without command.

Vehicle patrol: The dog is taught to ride in a patrol vehicle without interfering with his handler's duties or showing any aggression unless he is called upon by his handler for assistance.

Scouting and detection: The primary mission of a patrol/sentry dog while assigned to distant support posts is to detect and warn his handler

that an intruder is present in or near the area. To enable the dog to accomplish this task, he has been trained to alert on air borne human scent. Therefore, the wind direction and velocity is the most important single factor the handler has to contend with in employing his dog to the best advantage.

(a) Point to Point, initial scout training is accomplished by allowing the handler/dog team to walk a pre-determined route from one point to another. This patrol route is planned so that the dog can use his three main senses -- smell, hearing and sight. A decoy is hidden off the line of patrol on the upwind side. When the dog enters the scent cone, he reacts by showing a physical desire to follow the scent and search out the decoy.

(b) Scent cone, a scent cone results from the wind moving the scent from its origin, in a pattern comparable to that of an inverted cone. The velocity of the wind has a direct bearing on the length and width of the scent cone. For example, if the wind is 5 knots, the scent cone will be approximately 50 yards wide, 50 yards from the decoy. A 10 knot wind results in a 10 yard scent cone at 50 yards from the decoy. With a wind of greater than 10 knots the scent travels in a line rather than a cone.

(c) Quartering. Quartering is the method used by the sentry/patrol dog team to systematically clear an area. The handler walks through the area in a series of point to point patrol routes, beginning at the downwind boundary and progressing upwind until the area is cleared.

(d) Post Patrolling: Proper use of a dog requires that the handler devote most of his duty time along the downwind boundary of the area being secured. As a guide a distant support post being patrolled by a dog/handler team should:

- (1) Be patrolled only during the periods of reduced visibility, primarily at night.
- (2) Not exceed 200 yards in length.
- (3) Not exceed a 6 hour tour of duty.

Tracking: A dog will not necessarily keep his nose on the ground at the center of the track because fresh tracks can be easily detected on the downwind side by sniffing. Only on weak or old tracks is it necessary for the dog to put his nose to the ground to pick up the scent. There are four major contributing factors that influence tracking -- weather, type of surface, time of day, and presence of foreign odors.

(a) Weather: High temperature and sunny days result in unfavorable rapid evaporation. Southwind is considered best because it is warm and humid. North winds are cold and dry and are unfavorable to the retention of scent. Rain causes neutralization of odor and makes tracking extremely difficult or impossible.

(b) Type of surface and its condition is one of the most important contributing factors in tracking. The success of the dog depends largely upon it. For example, grass covered, planted, wooded areas or gravel roads are better to track through because the track disturbs the natural condition of the surface. Freshly plowed fields, sand, blacktop or cement roads and aircraft parking ramps are difficult because the surface offers

little or no variation in odor.

(c) Time of day: Evening, night and early morning are the most favorable (Early morning is considered the best.). Early morning mists are indicative of the earth's temperature being warmer than the air immediately above it. The earth is "exhaling" during this time, with very slow evaporation taking place, thereby offering the best tracking conditions.

(d) Foreign odors: Factors added by the individual passing through the area. These personal factors are what enable a dog to stay on a specific track.

(1) Personal smell comes through footware and clothing and saturates the ground. The shoe leaves odors of leather, tanning acid and material, polish and any substance the shoe was previously in contact with, i.e. a mechanic's shoe would most likely be saturated with oil, or a road maintenance man's shoe that has been continuously exposed to fresh black top and tar would leave strong specific odors.

(2) Walking or running: Running man leaves stronger tracks as more disturbance is created to the surface.

(3) Chafing of skin and hair leaves a deposit of these particles on the track.

Building Search: The dog has been trained to search a building off leash without the assistance of his handler. The dog will detect an intruder through a closed door and alert his handler by barking.

PROBLEM AREAS:

Tracking: Teaching a new dog to track is presently our greatest problem. This is most likely caused by our lack of knowledge and limited amount of experience in this area.

a. Specifically the problem lies in initial training where the instructor (who is unfamiliar with the dog) must find an incentive to get the dog to follow a track. It cannot be over-emphasized that a dog cannot be commanded to track. A desire to do so must be developed.

(1) One method of stimulating the dog is to lay a strong scent pad at the beginning of the track by scuffing the ground and dropping a scented article. Then continue scuffing the ground for approximately 15 yards, lay another scent pad, drop an article and continue on, stopping at intervals to repeat the process. Initial tracks should not be more than 75 yards in length. To prevent the dog from alerting on airborne scent, the track is never laid directly upwind. As soon as the decoy (track layer) is out of sight, the dog is brought to the starting point, the tracking harness and long leash is placed on him, and he is given the command to "track." The dog is allowed to follow the track at his own speed. As he examines discarded articles he is praised again and encouraged as he continues to follow the track.

(2) Another approach is to agitate the dog without allowing him the satisfaction of biting or chasing the decoy. A short heavy track is layed by the decoy as he runs from the area. The tracking harness is placed on the dog, he is brought to the scent pad left by the agitator,

and given the command to "track." As he begins to follow or show interest in the track, the handler encourages and talks to him in the same suspicious tone he would use in a detection type problem. At the end of a short track, the dog is allowed to chase and/or bite the agitator.

b. Variations of the above methods have resulted in approximately 50% of the dogs satisfactorily tracking by the end of the course. Because of the dogs natural instinct to sniff and examine the ground, we feel that the majority of the dogs can be taught to track within the 45 hours allocated to teach this subject if the proper incentive can be discovered.

TEMPERAMENT EVALUATION AND GRADING DATA

Capt Robert M. Sullivan
Commander, Det 37, HQ SAAMA

Since the beginning of history, dogs have accompanied their masters into battle. While it is easily recognizable that technological advances have changed the art of warfare to such an extent that current operations in Southeast Asia bear little resemblance to the conduct of warfare of only a generation ago, it is quite often forgotten that one of the mos' available, economical, and reliable weapons in man's arsenal has remained essentially unchanged during the entire history of war.

The military dog, although his skills have been improved by better training and exposure to a greater variety of tasks, still primarily performs the same tasks for which he was used by soldiers of thousands of years ago. Regardless of its branch of service or the type of training it has received, today's Military Working Dog serves one primary purpose. That is to detect and inform the handler of the presence of the object or individual detected.

While it is the individual service which establishes a need for Military Working Dogs and provides training to fulfill that need, it is the responsibility of the Military Working Dog Center to insure that a sufficient number of suitable animals are available for use.

In order to effectively select dogs which are suitable to meet the requirements of the individual services, the temperament evaluators assigned to the Center have defined general rules and principles which form the basis of selection.

Of primary importance the selection process must recognize that the Military Working Dog, like his human partner, must be motivated, trained, disciplined, and rewarded in order to perform effectively. That the dog, like his handler, but unlike any other animal known to man, requires emotional satisfaction in order to perform effectively. Every dog selected, therefore, must have the capability and willingness to share in the development of an emotional bond between itself and its handler.

As general rules, therefore, we require that every dog selected must be sociable, trainable, and identifiable. It is recognized that these terms are vague at best and clarification is required. Placed in the context used by the temperament evaluator however, the meaning becomes clear and the importance of these qualities are recognized.

Socialability: The Military Dog selected for training with a human handler must be capable of not only forming an association with his initial handler, but must also have the capability to transfer his affections and loyalties to a succession of handlers throughout his military career. Though a high degree of devotion and responsiveness must be given to his master, the dog must be capable of respecting the rights of other dogs and humans with which it may have contact.

Trainability: Each dog selected must be suitable for entrance into a number of varied training programs. Economic considerations alone dictate that the evaluator must be assured that prior to formal acceptance into the program, each dog possesses those traits necessary to complete one or more of the training courses.

Identifiable: Every dog selected must be capable of providing a reasonable amount of psychological impact upon the humans with whom it has contact. Through its physical appearance, conformation, and attitude, each dog must be capable of, with training, demanding respect from the potential enemy or criminal offender and instilling a sense of pride and confidence in its handler and other personnel with whom it will work.

In order to insure that each dog selected for the Military Dog Program conforms to the basic qualifications established by the Center, the evaluators look for signs of basic traits inherent in all dogs. These traits are ten in number and have been listed and explained on the attachment to this paper.

It should be noted that the attached grading data is provided to temperament evaluators as a guide only and is never used as a score sheet. No dog is expected to score superior in all subjects. No dog purchased should be perfect, but every dog should possess a combination of strong and weak points which, when observed by the experienced evaluator, will determine the type of training best suited to each dog. In that way, we contribute to every military dog handler's belief that his dog is the perfect dog.

GRADING DATA

Appearance

Superior: Clean, well-groomed, ears clean, no evidence of parasites, eyes clear and sharp.

Average: Needs bathing, grooming; evidence of parasites; appears healthy otherwise.

Marginal: Not evaluated

Reject: Evidence of skin disease, undersize, underweight, bad teeth, blindness

Conformation

Superior: Definite markings; good coat, height, weight; ears standing; hindquarters do not slope; tail high (tail showing also judged under willingness), position of feet straight ahead, wide stop, long wide muzzle

Average: Mixed breed; markings not definite; good coat, height, weight; one or more ears flopped or broken; short legged; tail position high or show position; wide or medium stop; average muzzle, dew claws

Marginal: Not evaluated

Reject: White or too light, coat too short or long, no undercoat, short muzzle, narrow stop, eyes narrow not facing forward, too short, underweight, tail curled protecting genitals (must be evaluated under sharpness also), not characteristic of breed

Gait (energy)

Superior: High degree of energy, works end of leash, appears to be searching, tail carried high, head held high, seeks side to side, steps long and high

Average: Accompanies handler without difficulty, appears interested, cautious, willing to move forward, tail carried high or level, head level or low searching

Marginal: Leash shy, collar shy, head, tail low, overly cautious, appears nervous, walks beside or slightly behind handler

Reject: Refuses to go, fear displayed in kennel,
fear bites, urinates or defecates while on
leash, grovels, head low, tail curled to
genitals, must be dragged on leash

Sensitivity

Superior:

Touch - responds actively to praise, appears to
enjoy physical play, enjoys and encourages
touching, scratching
Sound - responds to sounds, call of name, verbal
praise, correction, wants to investigate
strange sounds
Sight - watches activity of handler, watches
strangers, displays inquisitiveness at strange
sights

Average:

Touch - accepts physical praise, does not resent
physical play, appears to enjoy touching,
scratching, but does not seek it by nuzzling
Sound - responds to sound, not actively inquisi-
tive, appears to notice but is not concerned
Sight - notices activity, remains unconcerned,
does not react to approach of strangers, moves
independently of handler, does not seek direc-
tion

Marginal:

Touch - appears cautious with handler, flinches,
wants to play but unsure, appears unwilling to
make up to handler or stranger
Sound - knows sound of name but appears cautious,
flinches at strange noises, seeks protection
of handler, watches source of sound cautiously
Sight - worries over approach of strangers,
watches handler for encouragement, follows
rather than leads, shys from strange sights

Nose ability

Superior: Actively tracks, works nose constantly,
Wants to investigate, good air scent ability
Average: Will respond to ground scent, cannot work
track alone, air scents to seek location, good
air scent ability
Marginal: Not evaluated
Reject: Will not scout or track, refuses to work
scent because of fear

Willingness

Superior: Appears to understand instruction, accepts
correction, performs sit and heel with assistance
in three attempts
Average: Seems willing to try, understands instruc-
tion, correction, and praise, responds willingly
to instruction
Marginal: Appears cautious, resents correction,
seems handshy, displays fear at jerk of choke
chain
Reject: Obviously leash or handshy, displays fear of
correction, urinates, displays fear, self pro-
tection or fear biting at correction

Self right

Superior: Holds position regardless of what approaches,
appears willing to defend right to be there, does
not give way to another dog but does not challenge
Average: Seems willing to hold but needs assurance,
may break for another dog if challenged
Marginal: Gives ground to man or dog if challenged,
responds with active encouragement
Reject: Retreats quickly, drops to ground, seeks
protection, tail down, rolls on back, urinates

Confidence

Superior: Willing to make friends with strangers on
sight
Average: Will not make up with strangers who make
advances, but will make up on own after investiga-
tion

Marginal: Will not make friends unless given period of time to gain assurance
Reject: Obviously manshy, refuses to make up, retreats, may fear-bite

Fighting instinct

Superior: Appears to enjoy association with other dogs, appears inquisitive and comfortable, if challenged appears anxious to fight
Average: Will not seek or avoid fights
Marginal: Appears shy, will meet confrontation with assistance from handler
Reject: Will not meet a challenge at any time, displays attitude of subordination to other dog

Sharpness

Superior: Shows willingness to bite human on challenge, needs no encouragement
Average: Will bite when provoked, may need initial encouragement
Marginal: Will not bite but wants to, has fear of being corrected, would improve with confidence
Reject: Displays fear, will not bite, shows normal signs of insubordination, no self-right, poor confidence

WEIGHT CONTROL FACTORS

Lt. Col. James H. McNamara, USAF, VC
Staff Veterinarian for the
Directorate of Security Police
HQ USAF
Washington, D.C.

From an Air Force Security Police point of view, I am very pleased that this meeting is an actuality. As far as I know it will be the first time that both civilian and military research personnel have had an opportunity to meet with the various Air Force personnel associated with the Military Working Dog Program to cross-talk and orient the other in his area of interest.

There are approximately 8,000 dogs in the military service (Army, Navy, Marines and Air Force). The military working dog program, in many areas, is quite primitive. Until recently, the dog in general has been used as a tool of research but has not been investigated in the areas of limitations and capabilities relating to the dogs used as a detector or an extension of police work. A common belief has been that the Military Working Dog (MWD) is just another dog. It is difficult for many to realize that the trained Military Working Dog, regardless of type, is unique from a small animal medicine point of view.

The history of the MWD clearly indicates a development from an angry trained guard/attack/hold dog, to a nonangry, obedient detector that is rapidly becoming more sophisticated. The main objective of the Air Force Veterinary Service is to develop and maintain basic medical support, provide complete management control and as problems arise seek

out the answer to its cause, control and prevention. These actions are necessary to insure that the MWD will be maintained in top condition and has the capability to effectively respond to the daily requirements of the Air Force Security Policeman.

In my opinion the best index to condition and capability of the MWD is weight control. Eight years ago a major problem was underweight, resulting in poor efficiency, a high rate of days lost due to digestive and respiratory conditions, with a refusal to eat a portion of the daily ration. This was especially true in hot climates. A basic Air Force veterinary research study was set up to pursue the cause and prevention. Further studies indicated the cause was in two main areas: A) Nutritional requirements peculiar to the MWD; and B) Kennel design and environment. Today, from these studies, we are using new concepts successfully, which have resulted in a more effective working dog that has greatly extended the effectiveness of the Air Force Security Policeman. These are only two basic areas that require investigation and development. Many other areas should be studied as soon as possible.

NUTRITIONAL REQUIREMENTS PECULIAR TO THE MILITARY WORKING DOG

Studies indicate that there is an increased caloric requirement. Until recently, the nutritional requirement of the working dog has been based on and limited to pet standards. The working dog requires 31-50 calories (Kcal) per pound/dog/day, with an average of 35-40. The pet average is 25-35. The increased caloric requirement is due to increased energy requirements

due to total stress (physical, physiological and climatic). At the same time there is a reluctance of the animal to continually consume an increased weight and volume of food, as in the case of commercially available feed, when the animal is under max stress. Experience indicates that extreme heat and/or humidity are important factors in nutritional requirements and food intake.

Nutritional adequacy evaluation of a diet must be based on a daily individual dog basis. Each of the following must be considered: performance, weight control and the percent of daily ration consumed. Current National Research Council requirements are for the average pet. These standards cannot always be used for the Military Working Dog, the nutritional/caloric density is too low. Under extreme stress conditions, the military working dog would require three to four and one half pounds of pet food to obtain his daily requirement. In extreme climatic conditions, such as hot weather, the dog will only consume up to about two pounds. In this case only about 50% of the daily nutrient requirement would be obtained. The military stress diet is based on 1.25 pounds containing the daily nutritional requirement of a 80 pound dog under moderate to maximum stress. This amount is consumed without difficulty.

Comparing the pet and the military working dog: The former is represented by a wide range of breeds and varieties weighing 4 to 300 pounds with varying temperaments. The military working dog is confined to one breed-the German Shepherd. Only those individuals possessing certain qualities of health, temperament, and emotional stability are

chosen. The military working dog is trained and highly developed to respond acutely to certain stimuli. Continuous conditioning training is maintained. This results in the animal being under stress at all times. Nutrient requirements and formulation of diet under these conditions must be based on: A) The amount of each nutrient required per pound of body weight per day; and B) The diet must have sufficient nutrient density capability to enable the daily ration or amount consumed to provide the daily nutritional requirement, regardless of the degree of stress.

CALORIC DENSITY Various feeding trials and diet studies indicate that 2,500 calories per pound of feed is necessary to sustain the required daily intake, especially in extreme climatic conditions. Other nutrients must be adjusted in proportion to meet the increased density so the following requirements are met: The estimated nutritional requirements of the Military Working Dog is based on 1.25 pounds food intake per 80 pound dog per day. Caloric requirements vary due to environmental conditions.

TABLE 1: Caloric requirements at high temperature not to exceed 70% relative humidity, comparing commercial feed and high density/digestible stress diet.

TABLE 2: Caloric requirements at high temperature, 75-95% daily high relative humidity.

TABLE 3: Caloric requirements based on light, moderate and maximum stress (physical, psychological and climatic) of the military working dog vs. average pet.

TABLE 1: Caloric requirements at high temperatures (below 70 percent rel. hum.)

| Daily high temp. (degrees F.) | Relative humidity | Gross cal. per pound/dog/day Commercial Pet food* | Gross cal. per pound/dog/day High den./dig. stress diet | Calories/pound Commercial feed |
|----------------------------------|-------------------|---|---|-----------------------------------|
| 80 | | 40 | 30 | 1700 |
| 90 | | 45 | 35 | 1840 |
| 100 | | 50 | 40 | 1980 |
| 110 | | 55 | 45 | 2120 |
| 120 | | 60 | 50 | 2500 |

TABLE 2: Caloric requirements at high temperature, 75-95 rel. hum.)

| | | | | |
|----|----|----|----|------|
| 80 | 75 | 50 | 42 | 1700 |
| 85 | 85 | 55 | 46 | 1840 |
| 90 | 90 | 60 | 50 | 2500 |

TABLE 3: Caloric requirements based on total stress

| Stress | Nutrient | Amount/pound body weight/day | Amount per pound of dry feed |
|----------|---------------|---------------------------------|---------------------------------|
| | Energy (Kcal) | | |
| Light | | 30-50 | 2500 |
| Moderate | | 30-35 | |
| Maximum | | 35-40 | |
| | Pet average | 40-45 | |
| | | 25-30 | |

*Caloric density increased by addition of cotton seed salad oil

Caloric density, if too low, will result in the refusal of a portion of the daily ration, causing the actual weight to be substandard. As the daily high temperature increases above 80°F., the animal requires a reduction of total food volume and weight, with an increase in caloric density. The greater caloric requirement is in hot weather. There is a direct relation between the daily high temperature, humidity, caloric requirements and the caloric density of the ration.

The objective of the Air Force diet study was to develop a feed to meet the estimated caloric requirements of the Military Working Dog Diet, with a minimum quantity of food and provide all other nutrient requirements, especially in hot weather. Caloric requirements were based on previous food intake data using commercially available pet food. The original estimate was 50 gross Kcals per pound/dog/day. Based on the increased density/digestibility of the calories and various other ingredients in the military stress diet as compared to the commercial pet food, gross calories were reduced from 50 to 43, then 38 calories pound/dog/day which would maintain body weight; caloric density of pet food was increased by the addition of cotton seed salad oil.

PROPOSED MILITARY SPECIFICATION (INTERIM PURCHASE DESCRIPTION)

Based on findings associated with weight control and nutritional requirements peculiar to the military working dog, a Military Specification is presently being developed for "Feed, Semi-Dry, Military Working Dog." Distribution to industry and users is anticipated on or before 1 May 1970.

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The specification was developed to insure:

A. That the diet contained and provided the daily nutritional requirement per pound/dog/day.

B. That the diet was formulated to withstand the problems of distribution and storage peculiar to the military, world wide.

NUTRITIONAL REQUIREMENTS: The feed must be highly palatable. The nutritional density must be acceptable for the degree of total stress. The daily ration of the diet must provide the daily nutrient requirement based on: High minimum digestive coefficient percentage, proper nitrogen balance, controlled sodium content to control water intake and the daily vitamin/mineral requirement should be contained in 1.25 pounds of feed.

DISTRIBUTION AND STORAGE REQUIREMENTS: All dog food, especially high nutrient density diets, should incorporate control measures to prevent storage deterioration and loss of nutrient value such as: fat stability to prevent rancidity; grease-out or weeping control; bacteriology control, via standard plate count, not more than 50,000 at production and not more than 15,000 at delivery. The product shall be free of contaminating organisms; such as salomonella, fecal strep and E. Coli, indicating the wholesomeness of the raw ingredients. The product and containers shall be free of viable eggs and larvae of insects and mites. In addition, the date of pack, indicating the actual day, month, year will appear on all primary, secondary and master containers in letters not less than two inches high.

KENNEL DESIGN AND MANAGEMENT

If an animal continues to be underweight, and all feeding efforts have failed, kennel management and the dog's rest environment should be reviewed. The following basic check list should be considered: is the kennel environment quiet, comfortable, free of volatile gases and odors. Check the manner animal is handled, such as grooming, medical care attention and attitude of the handler. The military working dog is very sensitive and reflects handling and environment acutely. Insure that kennel and rest areas are maintained in a sanitary condition, sufficient clean water available at all times. The kennel must be free from distractions and disturbances. Construction design must include isolation confinement to prevent dogs from seeing each other and all other activity. In hot weather, dogs must be kept cool and comfortable during their rest periods. Sufficient shade and air circulation are necessary at all times.

If actual weight is below standard or arbitrary weight, with the refusal of a portion of the daily ration, the degree of stress should be determined. Total stress, (physical or work load; psychological, which relates to disposition; temperament, which is exhibited in degrees of calmness, nervousness or irritability; climatic, or the degree of heat, or daily high temperature above 80° F and 70% relative humidity.). To calculate the amount of high nutrient density food (2,500 Kcal/pound) in accordance with the degree of stress the following can be used:

MAXIMUM STRESS--divide the actual weight by a factor of four (4), the dividend will indicate the number of ounces of stress diet per day.

example $80/4 = 20$ ounces
 $60/4 = 15$ ounces

MEDIUM STRESS--divide the actual weight by a factor of 4.5, the dividend will indicate the number of ounces of stress diet per day.

example $80/4.5 = 17.7$ ounces

LIGHT STRESS--divide the actual weight by a factor of five (5), the dividend will indicate the number of ounces of stress diet per day.

example $80/5 = 16$ ounces

For underweight dogs increase food 10% per week until desired standard is obtained. For overweight dogs reduce feed 10% per week until desired standard is obtained.

CLOSING: In addition to the above areas, nutrition and kenneling, other problems that should be considered for investigation or research are as follows: 1) Countermeasures--or factors having a detrimental affect on the behavior of a working dog. i.e. What will divert attention from tracking, effect senses. 2) Methods to aid handler to detect early alert, i.e. visual electronic, other, etc. 3) Procurement selection/Training methods. Investigate procurement age, preconditioning in health, weight and control training. Review and investigate the training methods to determine best methods, sequence of training etc. to reduce the training time with an improved end product. 4) Factors affecting olfactory senses--determine substance, degree of loss of smell and time factor.

5) Cold weather studies: To determine the temperature range that a military working dog can perform effectively. 6) Sound studies: Determine the maximum db, frequency range and time factors a dog can be exposed to without resulting in a detrimental effect.

VETERINARY ASPECTS OF MILITARY WORKING DOGS

Major Roland C. Olson, USAF, VC
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Wilford Hall USAF Medical Center
Lackland AFB, Texas

Dog training responsibility was transferred from the Army to the Air Force at Lackland Air Force Base, Texas, in 1958. The peak Air Force use of dogs was in the late 1950's and early 60's to provide added security to the bomber bases of Strategic Air Command throughout the United States and portions of Europe. With increased involvement in South East Asia, the Army reactivated its scout dog program, the Marines and Navy wanted dogs for security and scouting duty and the Air Force need for dogs took a big jump because of the difficult security problems at many of our bases in Viet Nam. Today, approximately 5,000 dogs are in use throughout the defense department, over half of them in South East Asia.

Under present Department of Defense policy the Air Force is the single agency for procurement of military working dogs. All dog evaluation, processing and procurement activities are accomplished at the Military Working Dog Center, Lackland AFB, Texas. Also located at Lackland AFB is the Air Force Patrol Dog Training School, which is the largest dog training school in the Department of Defense. Kennel capacity at Lackland, including both the procurement and training activities, is approximately 900. The most dogs that have ever been on hand at one time has been 758 -- generally the kennel population ranges between 450 and 600 dogs. The Military Dog Veterinary Service, with a staff of six

veterinarians and 20 technicians performs the physical examinations of all new dogs and provides medical care for all the dogs at Lackland. A new veterinary clinic, specifically designed for the processing of new military dogs was completed at Lackland AFB in April 1968.

With very few exceptions, German Shepherd type dogs are the only dogs presently used by the various branches of service. The Shepherd has been bred for years as a working dog and has the stamina, temperament, natural protectiveness and keen senses that enable them to perform outstandingly as military dogs. Specifically, the Shepherds double hair coat enables him to adapt quickly to extreme climate changes and his keen hearing and smell make him effective for military purposes in that he can alert, routinely, up to 250 yards. From a procurement standpoint, as the second most popular registered dog, the Shepherd is readily available for purchase throughout the country.

Basically, to be considered for military duty, dogs must be 12-36 months of age, 23 inches high, with a minimum weight of 60 pounds. Either male dogs or spayed females are acceptable; the dog need not be a registered shepherd but cannot be all white in color.

Dogs are purchased for up to \$150.00 from individual owners throughout the country who hear of military needs through various types of advertising. Most of these dogs have outgrown their home for one reason or another and are sent to the Air Force rather than being euthanized or turned over to a dog shelter. Occasionally, dog buying teams are sent to large metropolitan areas for 3 or 4 day dog "buys," which in conjunction with heavy

publicity, helps to supplement routine dog procurement. No breeding of dogs is conducted at the Military Dog Center and there are no suppliers under contract to furnish dogs to the military.

The working life of Air Force dogs averages out to approximately 7 years. As handlers are discharged, new handlers are trained on the dog; most dogs will have 5 or more handlers during their service career. Very rarely is it impossible to train a dog with a new handler and every attempt is made to do so, even with the most fractious dog. When a dog reaches the point where he is no longer physically or mentally able to perform military duties the dog is euthanized. Most dogs perform effectively up to about 9 years of age; 12 or 13 years is the extreme. Dogs, once trained, are not returned to civilian life. Considering the training these dogs have received, it is obvious why this is not done.

PROCESSING NEW DOGS

Before a dog is shipped to Lackland Air Force Base as a prospective military dog, the dog is required to have a preshipment physical examination, preferably including a pelvic radiograph, performed by either a military or civilian veterinarian. Results of the preshipment examination are sent to the center and reviewed by military veterinarians prior to sending for the dog. In 1969, 1,950 preshipment physical examinations were reviewed and 577 prospective dogs were rejected for physical deficiencies revealed by the preshipment examination. By far the leading cause of preshipment rejection was due

to the dog having hip dysplasia of Grade II or greater severity. Thirty percent of prospective dogs were rejected prior to shipment to the center; 69 percent of the rejections were due to hip dysplasia, 9 percent due to Filariasis, and 8 percent due to bad teeth. Other leading causes were undersize, and wrong breed. The hip dysplasia reject rate becomes more significant based on the fact a total of only 1,126 radiographs were reviewed out of 1,950 exams and 394 or 35 percent were rejected for having hip dysplasia of Grade II or greater.

If the preshipment examination of the dog does not reveal any disqualifying defects, an aluminum shipping crate is sent to the owner and the dog is shipped by air freight, at government expense, to San Antonio.

A dog's medical records are established and a unique brand number assigned prior to the arrival of the dog. Immediately upon arrival at the center a new dog is checked by a veterinary technician for any obvious signs of illness or injury and the technician gives a Bicillin injection to the dog. Within 24 to 48 hours the new dog is brought into the veterinary clinic for a complete stand-up physical examination. A blood test for microfilaria is performed and the dog is immunized for rabies, distemper, hepatitis and leptospirosis. If the dog passes his formal entrance physical examination, the next step is temperament and gunfire testing which is done by military police assigned to the dog center. Providing the first two test phases are passed by the dog, the last step is another complete physical examination, accomplished under anesthesia and including a pelvic radiograph to determine the status of the dog's hips. If this final examination is

successfully passed by the dog, his teeth are cleaned, dew claws removed and a unique tattoo is placed in the left ear. In FY 69, out of 2,189 dogs arriving at the center, 1,003 were rejected, for an overall reject rate of 45.8 percent; 446 or 20 percent were rejected for temperament reasons, and 557 or 25 percent were rejected for medical reasons. Specifically, 55 percent of the medical rejections, 305 dogs, were for hip dysplasia of Grade II or greater. Two reasons account for the high hip dysplasia reject rate experienced at the Center -- (aside from the fact many German Shepherds have dysplasia) -- are that about 1/3 of the dogs examined were not radiographed prior to their arrival at the center and a smaller percentage of those dogs that did have preshipment radiographs were done so poorly that we could not make an accurate determination of the condition of the dogs' coxo-femoral joints prior to their arrival at the center. In descending order, other leading causes for medical rejection were: 1) broken/worn teeth - 13%, 2) undersize/underweight - 10%, 3) filariasis - 6%, 4) elbow dysplasia - 4%, and 5) eye problems - 1%. Rejected dogs are either returned to the owner at government expense or are given away to new owners in the San Antonio area.

DOG TRAINING

Most dogs purchased at the Military Dog Center enter the Air Force Patrol Dog Training School, also located at Lackland Air Force Base, Texas. Approximately 200 handler/dog teams are in training at any given time. The Military Dog Veterinary Service provides medical care to the

dogs in training -- routinely this involves collar burns, dog fight wounds, sore pads, parasite control, and the like. Equally important, instruction on health, first aid, preventive medicine and preventive dentistry is provided by veterinary officers to the students. Three hours of classroom lectures are given on health and first aid; about two hours of field demonstrations, with students practicing on their own dogs, are given in preventive medicine and dentistry. Students are taught how to take a dog's temperature, how to pill dogs, apply ointments, give liquids, etc. We also anesthetize several dogs in each class and instruct students in the proper method of removing dental calculi from dogs teeth. Most students, after establishing rapport with their dogs, are able to scale their own dog's teeth without any anesthesia or any particular problems in controlling the dog. This practice saves considerable amount of "down" time for the dog out in the field.

VETERINARY PROBLEMS

The greatest medical problem, by far, associated with military working dogs is that of hip dysplasia. Hip dysplasia is the largest single cause of dogs not being acceptable for military duty and is the leading cause for premature disability in trained working dogs. Somewhere in the neighborhood of 4,000 pelvic radiographs are reviewed every year by veterinarians at the center -- about 1,500 of these are preshipment radiographs, the other 2,500 are pelvic radiographs taken at the center during procurement processing or examination of dogs returned to the center for purposes of retraining. Two obvious factors are of significance in pelvic radiography

of dogs for the diagnosis of hip dysplasia. The first is correct positioning of the dog and proper radiographic technique; the other factor, which cannot be done without a diagnostic radiograph, is the ability to interpret the degree of dysplasia which may or may not be present in the dog.

A complete mechanical method of restraint is employed for positioning of dogs during pelvic radiography at the center. The use of mechanical restraint results in consistent, uniform radiographs of the many dogs radiographed throughout the year. Technicians perform all the pelvic radiography at the center; it is much easier for them to learn how to position dogs mechanically than it is to attempt to teach them how to hand position a dog for radiography. Experience has shown that hand restraint of dogs results in great variations in positioning even when the same individual does the positioning. Also of importance, mechanical restraint eliminates the exposure of personnel to x-radiation that occurs when dogs are hand held. Technique employed is as follows: The dog is anesthetized with Innovar Vet and 2% pentathol and held in the VD position by V-pans and a strap across the chest. A five pound sandbag is attached to each rear leg, the stifles are rotated medially by a strip of adhesive tape and the rear legs are pressed down on the cassette by a large sandbag placed across them. A technician can position, radiograph and remove a dog from the table in about two minutes. This procedure follows the positioning guidelines outlined by the A.V.M.A. Council on Hip Dysplasia, published in 1961.

The dogs pelvis is measured with a calipers and the KVP setting is determined by the thickness of the pelvis.

The A.V.M.A. standards and grades of Normal, I, II, III and IV are used in determining the degree of hip dysplasia in dogs examined at the center. Dogs are purchased with normal and Grade I hips; Grades II, III and IV are rejected. Experience has shown that dogs entering service with Grade II or more severe dysplasia usually break down so rapidly as to make it economically unsound to purchase this type of dog. Many dogs are now being returned to Lackland AFB for retraining after being out in the field for varying lengths of time. These dogs are all reradiographed and their current radiograph compared to their entrance radiograph. Much more refinement of data needs to be done; however, on over 500 dogs examined in this manner it is becoming apparent that dogs normal at purchase tend to remain normal whereas dogs Grade I at purchase tend to degenerate to Grades II and III over variable lengths of time. The A.V.M.A. numerical system of grading hip dysplasia is more useful than the O.F.A. Normal, Near Normal and Dysplastic system in describing and defining degrees of hip dysplasia for military purposes. The O.F.A. catagory of "near normal," from experience at the center, covers roughly the A.V.M.A. catagory of moderate Grade I to early or moderate Grade II. A few dog owners become upset when their dog, judged "near normal" by the O.F.A., is rejected for military service because of Grade II dysplasia.

Elbow dysplasia is another skeletal abnormality for which dogs are closely screened before purchase. While the dog is under anesthesia the elbows are palpated for crepititation or reduced arc of flexion. If

crepitation is felt or it is not possible to touch the point of the scapula with an extended finger of the hand holding the corpus there is usually pathology of some type present. Only dogs in which pathology is suspected are radiographed for elbow dysplasia.

PREVENTIVE AND RESTORATIVE DENTISTRY

This has become very important in extending the working life of military dogs. Loss of teeth from wear, trauma or extraction has made young dogs ineffective. Teeth, especially the canine teeth, are a primary weapon of the military dog. In the past, canine teeth broken or worn to the point of pulp exposure were either extracted or left in place without therapy being attempted. Once a tooth has been damaged and the pulp exposed, bacterial decay and apical abscessation usually follow rapidly. Extraction is a last resort because of loss of function, tongue lolling, and stress placed on the remaining teeth and the gingival tissue. If 1/4 to 1/2 inch of a canine tooth can be salvaged the dog retains much of his ability to bite and hold. Working with endodontists at Wilford Hall USAF Medical Center, veterinarians at the Dog Center have modified human endodontic procedures for stabilizing and salvaging damaged canine teeth. The procedure consists of removing the dental pulp, cleansing the pulp canal, and filling with a zinc-oxide/eugenol paste; an apicoectomy in which 3-4 mm of the apical end of the root is removed; and an amalgam sealing of the pulp chamber at both ends. Surgical defect repair is rapid and the dogs have to be held off attack work for only two to three weeks. All instruments are standard human

dental instruments. The procedure involves about 45 minutes per tooth and barring further severe trauma to the tooth the repair should last for the lifetime of the dog.

Heartworms are a continuing problem both in procurement of new dogs and in infections occurring in dogs working in endemic areas. All USAF dogs are checked for heartworms a minimum of every 6 months and dogs at the Center are checked monthly. A modified Knotts test is used for detection of circulating microfilaria and to differentiate microfilaria of D. immitis from microfilaria of other apparently innocuous filarial parasites such as Dipetalonema. Length, width and body morphological features are used to differentiate the filarial parasites which may be present in the dog.

Over 100 dogs have been treated in the past year at the center for active D. immitis infections. Therapy consists of Na Caparsolate bid at 1 cc. per 10 pounds given IV for two days. If no problems from the Caparsolate appear within three weeks, the dog is given a microfilaricide -- either Dizan at 10 mg/lb daily for two weeks or Talodex 2 s.c. injections at a two-week interval. The dog is considered cleared after 4 negative Knotts exams are obtained weekly starting one week after cessation of microfilaricide therapy. Destruction of microfilaria is not felt to be particularly necessary for the health of the individual infected dog, however it is an indication of the successful destruction of the adult worms and also eliminates a reservoir of infection for other dogs in the kennel. It has been observed at the center that approximately five percent of dogs that have adult D. immitis present on necropsy have a history of

never being positive on a Knotts exam. In the past year two necropsies have revealed adult D. immitis worms lodged in the arteries of the brain.

Several years ago, at the time dog procurement activity rapidly increased, an epizootic of a highly contagious but rarely fatal upper respiratory infection occurred in the dog population at the center. Typical signs were a nasal discharge, moderate temperature elevation, cough and occasionally pneumonia. No matter what combination of antibiotic and supportive therapy the dog had, they were listless, off feed, and the disease usually lasted 2 to 4 weeks or longer. An SV-5 virus was eventually isolated and felt to be the primary etiologic agent along with various types of secondary bacterial invaders. The dogs' resistance to the disease was lowered due to stress of shipment and to the overcrowded kennel conditions experienced at that time. The presence of URI has gradually disappeared over the past 18 months; other than luck or a natural down cycle in virus activity, we can attribute the disappearance of URI to a much improved kennel situation, a better diet and the fact that all newly arrived dogs now receive a bicillin injection to help them over the post shipment stress period.

Weight loss has always been a problem in highly strung military working dogs. Presently available commercial type dog foods, although they are gradually improving, generally are not quite adequate for the working dog. In order to supply the needed calories and protein to maintain a working dog in good flesh, a large amount of food had to be fed daily. This led to refusal problems, g.i. upsets and all too frequently acute bloat with

an occasional death. Feeding of military dogs in combat situations, particularly dogs which may be operating away from fixed bases, such as scout dogs, can become a particularly difficult problem. Air Force veterinarians have worked with Mark Morris Associates in developing a ration specifically designed to meet the nutritional requirements of the stressed military dog, and other military packaging, transportation and storage requirements. As a result a ration known as Military Stress Diet has been developed and in use for over a year. MSD has a caloric density of approximately 2,500 calories per pound, contains 29% protein, 26% fat and 11% moisture. A military dog can be maintained on 1 to 1-1/2 lbs. of MSD daily, depending on the dogs' weight. This amount is roughly half of what is necessary when a dog is fed a commercial diet and our dogs maintain their weight, condition and hair coat on MSD much better than on any previous diet utilized. In an effort to control intestinal parasites and heartworms, experiments are presently being conducted on adding a drug combination, styrylpyridinium and diethylcarbamazine, directly to the MSD diet during the manufacturing process. All dogs would then receive a low level of both drugs in their daily diet. So far, close to 100% elimination of hookworm infection has been achieved and other intestinal parasites have been significantly reduced. The medicated diet has not been used long enough to test its effectiveness in control of heartworm transmission.

U. S. AIR FORCE INFORMATION SHEET

MILITARY DOGS

FEBRUARY 1970

INTRODUCTION

Throughout the history of warfare, up to the current action in Vietnam, dogs have gone into combat or have been used in direct support of combat operations. Initially, entire formations of attack dogs, frequently equipped with armor and spiked collars, were sent into battle against the enemy. With the invention of gunpowder and the consequent change in military tactics, the value of the dogs in combat diminished. However, his usefulness in other military activities increased. During World War I, vast numbers of dogs were employed as sentries, messengers, ammunition carriers, scouts, sled dogs, and casualty dogs. It is estimated that Germany employed over 30,000 dogs for such purposes, and approximately 20,000 dogs served with the French Army. The American Forces had no organized dog unit but borrowed a limited number of dogs from the French and Belgians for casualty, messenger and guard duty.

During World War II, dogs were used on a larger scale. Over 250,000 dogs served with the armies of the Allies and the Axis Powers. The need for dogs in large numbers was recognized by the Army in 1942 and resulted in the establishment of the K-9 Corps. This organization operated five War Dog Training Centers throughout the United States and trained approximately 10,000 dogs. The Patrol/Sentry Dog Training Branch, Department of Security Police Training, Lackland AFB, Texas, was established in 1958. Today, patrol/sentry dogs are trained at Lackland for all of the U. S. Armed Forces. The Air Force is the Department of Defense's sole user of patrol dog teams. Sentry dogs are used primarily by the Army, Navy, and Marines.

TRAINING SCHOOLS

Sentry and patrol dog teams are trained at Kadena AB, Okinawa; Wiesbaden AB, Germany; and Lackland AFB, Texas. Scout dogs

are trained at Fort Benning, Georgia. Scout dogs are used primarily by the U. S. Army as an advanced patrol while on scouting missions. Handlers who attend the Sentry Dog Course train for eight weeks. Prospective patrol dog handlers attend a 12-week course of instruction. In addition to the actual training with a dog, all handlers must receive instructions in psychology of dogs, prevention of canine diseases, first aid and care of dogs, and principles of dog training.

BREED OF DOGS USED

The German shepherd dog has been selected as the breed best suited to the needs of the Air Force. This determination was based upon the German shepherd's demonstrated possession of the following traits: keen sense of smell, endurance, reliability, speed, power, tracking ability, courage and ability to adapt to almost any climatic condition. As a recognized breed, German shepherds are relative newcomers to the canine world.

The German shepherd is a working dog; strong, agile, well-muscled, alert, and full of life. He is longer than he is tall, and has a deep body with an outline of smooth curves, rather than angular. The ideal male is 25 inches high and weighs between 75 and 85 pounds; the bitch is two inches shorter and approximately 15 pounds lighter. This dog has a distinct, direct, fearless, but not hostile expression; a self-confident personality, and a certain aloofness that does not lend itself to indiscriminate friendship. He is a trotting dog. His long effortless trot covers maximum ground with a minimum number of steps, consistent with the size of the dog. Good conformation calls for firmness of back and muscles, and proper angularity of forequarter and hindquarter.

BEHAVIOR AND INSTINCTS

The dog's world differs from the human in some very specific ways. His world is predominately one of odors. His nose tells him countless things about the environment that entirely escapes humans. He is more sensitive to sounds. His vision is considerably inferior to human vision and for this reason he depends less upon it. He prefers to approach closely to objects that must be examined. However, his sensitivity to the movement of objects compares favorably with human sensitivity. To find a dog's ability or quality in a particular trait, it must be sought directly. To discover whether a dog is gun-shy, he must be tested with a gun. To

discover whether he is intelligent and willing, he must be trained. At present there is no reliable shortcut.

TRAINING

The trait which sets dogs apart from all other animals is their willingness to work for a reward of a most intangible nature - the approval of the experimenter. No rodents, cats, raccoons, monkeys, or apes have appeared anxious to please the scientists who strive so earnestly to study them. For these animals, the reward must be something of a practical nature, such as food or the punishment. Canine subjects usually become attached to the experimenter who finds that a casual caress can be a remarkably effective reward; a disappointed or disapproving word is a potent punishment. Even anticipation of such disfavor clearly controls the dog's behavior.

Working dogs provide opportunities to observe the efficacy of "intangible" reward and punishment. Once the handler-dog relationship has been established, there is brought into play that motivation which finds its roots in the sentimental attachment of canine for man. Concrete punishment and reward are still used, and may be necessary on occasion, but to a large extent these may be abandoned. It is more pleasant and more convenient to rely upon the dog's eagerness to serve. Complete scientific explanation of this eagerness has not been attained. The important thing is the actuality of this trait. The entire training of dogs is based upon a proper use and development of the natural instincts of the dog, demonstrated by the following:

1. The dog's instinctive companionship for man is turned into comradeship with one handler.
2. The dog's instinctive response to human attitudes is used as the basis of training; the dog is praised and encouraged when he does well and is corrected and reprimanded when he does badly.
3. The dog's instinctive urge for prey forms the basis of the sentry dog's actions; the instinctive urge to pursue anything which runs from him is the means by which the dog's urge is made effective. **VOCAL COMMANDS:** Vocal commands are given firmly and clearly. Tone and sound of voice, not volume, are the qualities that will influence the dog. It is essential that the dog be made to

carry out the same command over and over until the desired response is obtained without delay. Repetition is more important in dog training than in human training. The trainer must never lose patience or become irritated. If he does, the dog will become hard to handle because he takes his cue from the handler, but it must be coupled with firmness. Obedience must be demanded if the dog is to be a prompt and accurate worker.

From the very beginning of training, the dog should never be permitted to ignore a command or fail to carry it out completely. He must learn to associate the handler's command with his execution of it. He should never be allowed to suspect that there is anything for him to do but obey. Laxity on the part of the handler may result in an attitude of mood of disobedience that means difficulty and delay in the training program. A dog does not understand right and wrong according to human standards. Rewards and punishment are the means of teaching him the subject areas desired. Real punishment should be inflicted as a last resort and only for deliberate disobedience, stubbornness or defiance. He must never be punished for clumsiness, slowness in learning or inability to understand what is expected of him. The word "NO" is used to indicate to the dog that he is doing wrong. "NO" is the only word used as a negative command. If this form of reproof is not successful, the dog should be muzzled, chained or kenneled. A dog is never slapped with the hand or struck with the leash. The hand is an instrument of praise and pleasure to the dog and he must never be allowed to fear it. Beating with the leash will make him shy of it and lessen the effect of its proper use.

SENTRY DOG

A sentry dog team consists of the handler and his dog. A security policeman who is a sentry dog handler in no way loses his identity as a security policeman. A sentry dog handler is merely a security policeman who has received additional training which qualified him to utilize an item of special equipment, a sentry dog.

The sentry dog team is used to increase security of such areas as distant perimeter posts, ammunition dumps, warehouse areas and isolated radar sites. When on post, a sentry dog's primary function is that of detection and warning device. This function has been performed when the sentry dog detects and alerts his handler to the presence of an intruder. The secondary function of the sentry dog is to pursue, attack and hold any intruder who attempts to evade or escape from apprehension.

PATROL DOG

In recent years, the experiences of military dog handlers in Vietnam have demonstrated that the sentry dog, as it is trained today, does not possess those skills needed to successfully pursue the combat role in Southeast Asia. Since the inception of the USAF Sentry Dog Program in 1952, dogs have been trained to provide a physical and psychological deterrent against those who would attempt penetration into USAF restricted areas. Primarily a defense against the possible saboteur or espionage agent, the sentry dog team worked well and provided base security forces with an early detection capability which would have been impossible otherwise.

Southeast Asia, however, has presented a new set of problems in the concept of air base defense where the sentry dog team has little or no psychological impact and where, upon detection, the enemy force is seldom reluctant to engage the security forces. Soon after the introduction of sentry dog teams into South Vietnam in 1965, it was recognized that additional skills would have to be developed in order to enable the dogs to become a more flexible and effective aid to our security forces.

What was needed then was a dog team which would:

1. Detect the presence of an intruding force by sight, sound, or scent and be capable of alerting, surveilling, attacking or withdrawing at the option of the handler, without detection by the enemy force.
2. Accompany security forces in pursuit situations such as the Tan Son Nhut "mop-up" of 5 - 6 Dec 66, and assist such operations by scouting or tracking.
3. Work in close proximity with friendly forces as the member of a Security Alert Team, patrol or ambush without becoming distracted or agitated, and with complete safety to the other members of the force.
4. Expedite the transfer of handlers in a rapid transfer situation. In the attempt to establish a training program that would provide these skills, it was determined that the familiar city police dog when trained for a military application, could not only perform these required tasks but would enable Security Police units to use dogs more effectively for the protection of resources, property and personnel in all phases of

security police work. In the development of a more effective combat dog team, it became immediately apparent that these additional skills could be effectively used in the prevention of thefts, pilferage, in criminal investigations and with complete confidence and safety in riot and crowd control.

What the patrol dog can do for the security police can be most easily demonstrated through a comparison of the patrol dog's capabilities with those of the present day sentry dog:

1. The sentry dog will detect penetrations of his post, alert his handler, and if necessary, pursue, attack and hold an intruder who attempts to escape.
2. The patrol dog, on the other hand, is a composed, discriminating, controllable and observant animal, capable of detecting and detaining unauthorized personnel in both combat and criminal situations. The patrol dog is trained to work with a combat unit or among base personnel and their dependents, on or off leash and with complete safety. In addition to performing sentry dog duties they are trained to locate hidden persons in large buildings or open areas by airborne scent. They can be used to track criminals from crime scenes, or find lost children by following scent tracks which may be 24 hours old or more. They are capable of locating lost, abandoned, or hidden articles, no matter how small. They will attack only on command, without savaging, and can be called off an attack if necessary. Finally, they can be used with complete safety to control crowds or disperse large, unruly mobs. What we have then is a military dog, well trained and ideally suited to be used in all phases of security police work.

CAPABILITIES OF MILITARY DOGS

The German shepherd, besides having an IQ comparable to that of a seven-year old child, has a capacity for learning about 100 commands. The trained German shepherd has a bite equal to 400-700 pounds per square inch of pressure. A dog's sense of smell so far surpasses that of man's, that it is nearly impossible to comprehend the difference. If a dog wishes to examine an object, he moves downwind to take advantage of his keenest sense-smell. A dog's hearing ability is about 20 times better than that of man. He can detect sounds above and below the pitch a human is capable of hearing. With the exception of his ability to detect movement, a dog's vision cannot be compared favorably with that of the normal human. To the dog everything probably appears to

be constantly out of focus. He is most likely unable to discriminate between colors. He sees everything as a black and white or grayish picture. He can, however, detect a moving object when it is moved ever so slightly, and will respond to this movement.

Because dogs are used primarily at night, vision is of limited importance during working hours. While working, a dog's effectiveness depends mainly upon his senses of smell and hearing.

MILITARY DOGS CITED

YORK

Army Scout Dog York has been credited with leading 148 advanced combat patrols in Korea without the loss of a single man due to enemy gunfire.

NEMO

There have been many instances of sentry dogs performing heroically in the face of danger. A sentry dog named Nemo was no exception. The war in Vietnam ended in December 1966 for sentry dog Nemo. On 5 December 1966, Nemo and his handler, Robert A. Throneburg, then an A1C, were on a routine patrol at Tan Son Nhut AB. The base had been hit the day before by a Viet Cong mortar attack. The main enemy force was turned back by the 377th Security Police Squadron's main line of defense. But four infiltrators eluded detection by earlier search parties and hid inside the base's perimeter. Airman Throneburg and Nemo were assigned to search for the intruders. The search ended when Nemo detected the hidden Viet Cong. At Throneburg's command Nemo lunged savagely for the enemy. The pair quickly killed two of the enemy. But before additional security police could reach them, handler and dog were both wounded. Nemo was credited with saving the life of his handler and preventing further destruction of life and property at Tan Son Nhut.

RECRUITING

The increasing need by the military for scout, sentry and patrol dogs, both abroad and in the United States, has stimulated a new recruiting campaign. Approximately 2,000 dogs are trained each year at the Lackland facility. Dogs must be German shepherd (but

need not be pedigreed), male or spayed female, one to three years old, weigh 60 pounds or more and stand at least 23 inches at the shoulder. Females must have been spayed for at least 90 days prior to acceptance. White dogs are not accepted because they are likely to reveal the position of a sentry at night, and they are more prone to skin disorders.

Owners who wish to sell or donate German shepherd dogs should contact the Military Working Dog Center, Detachment 37 (AFLC), Lackland AFB, Texas 78236.

II. Scientific Research Related to
the Military Working Dog Program

ASPECTS OF CONTROL AND PERFORMANCE MONITORING

Howard A. Baldwin
Sensory Systems, Inc.

The following is an outline of the research investigation proposed under Air Force Grant AFOSR-70-1897, recently initiated. This investigation is an exploratory study aimed at greater utilization of sensory ability in animals. It incorporates direct monitoring of the psycho-physiological responses to alerting stimuli with an investigation of the optimum conditioning modalities in dogs. It is intended to demonstrate that an untethered dog can be used as an effective remote sensor and that his perception of specific stimuli can be remotely observed by telemetry without the need of overt action on the part of the animal. The research effort will be undertaken with as much interaction as possible with ongoing dog training objectives at Lackland AFB, and with Project THEMIS at the University of Mississippi. Laboratory evaluation of conditioning methods and sensory acuity is particularly appropriate for the THEMIS program.

Research Objectives

I. P. Pavlov described an investigatory reflex in dogs (also called orienting or alerting response), which is common to most living systems. It occurs subsequent to a novel or startling stimulus and results in pronounced short term physiological changes in the animal. These include changes in sensory thresholds, heart rate, postural reflexes, breathing rate changes and redistribution of the peripheral blood flow. Of these various transient responses we suspect that rapid redistribution of the blood flow is the most definitive indicator of alerting behavior. It is observed as a vasoconstriction in the peripheral surface of the body and a vasodilation in the head and brain. While capillary blood flow is difficult to measure directly, a change in blood flow is easily detected with heat sensors as a change in temperature. We have observed thermal responses to alerting stimuli in a number of wild animals -- lion, elephant, wolf, penguin, and recently the Arctic fox. We have also observed dramatic redistribution of blood as indicated by surface body temperature in a trained bird dog during a "point", and we believe we have been able to distinguish this

trained reaction from other alerting responses. From this experience we believe that the threshold, magnitude and duration of blood flow shifts can be enhanced with operant conditioning and can be, in fact, triggered by conditioned rather than unconditioned stimuli.

This study is framed in terms of a specific objective--to develop the training and technology necessary to guide a dog to search for an object or situation and communicate its acquisition through physiological telemetry. The final task is intended to be undertaken without physical contact between the dog and the investigator. A description of the instrumentation concept is as follows:

1. A transmitter will be available to the trainer which will communicate to the dog through a collar mounted receiver.
2. A transmitter and physiological sensor on the collar of the dog will telemeter physiological reactions from the dog to the base station receiver-recorder and display system available to the trainer.
3. An electrical plotting system will monitor the position and movement history of an instrumented free-roaming dog, and provide a physical display in real time of the dog's position on a chart. A control system in the display will be capable of determining and controlling the limits of the dog's movements.

This equipment is intended to demonstrate the feasibility of the objectives of the proposal within a limited time period. Certain assumptions with regard to the presentation of stimuli to the dog (their form, timing and duration) will have to be made empirically during the initial phases of the study.

Communication Coding

Let us consider now in more detail that aspect involving the communication channel from the trainer to the animal. In current practice the dog-trainer relationship is physical, vocal and behavioral. The man controls his animal at close range using a more or less natural language--voice commands, body

movements and tactile interaction--in a generally natural, simple and certainly reliable form of communication. Nothing presented in this research plan is intended to supplant these methods until a new method can show a demonstrated advantage.

Consider the dog as an array of sensors--olfactory, auditory, vibratory and visual. His brain is an adaptive computer capable of intense but brief periods of concentration, comparative analysis, and decision forming logic. He certainly is a portable self powered physical mechanism. Are the common communication codes adequate to employ the dog in optimum usefulness? Is it possible that the genetic development of the canine brain and body has a utility and richness not yet realized in the man-animal relationship because we have insisted on using the spoken language, a unique human accomplishment, in addition to a more fundamental primary action language? In one practical sense the communication from man to animal is limited to a rather short effective range and only the auditory command is useful in periods of darkness.

No one would question the value and importance of radio communication in the man-to-man relationship. Certainly it would appear to be worth investigating for the situation where commands are necessary for behavior control with an off-leash dog out of range and sight of the trainer. Let's assume for the moment that the telemetry command channel does exist. What is the form of the communication that might be conveyed? I think it might be appropriate, initially at least, to separate the man-animal communication channel into two major vocabularies, which might be designated as: (a) the conditioning vocabulary, and (b) the operative vocabulary. I think that both of these vocabularies will be rather limited. I have selected five words for the conditioning vocabulary, as follows:

Problem
Encouragement
Reward
Warning
Punishment

The operative vocabulary will consist of an expanding array of subroutines which, as the dog learns them, are identified by a specific vocabulary word. The following are examples:

Hold
Return
Continue

The conditioning vocabulary is intended as a tool through which the trainer communicates the learning or shaping of the dog's behavior patterns. The word "Problem" defines the initiation of a learning sequence and it would be used only to shift the dog's attention from current activity by announcing the onset of a training or learning task. Notice that this command is somewhat similar to the placing of a special collar on the neck of the animal, or the action of removing a leash. It is intended, however, as a cue not only during the initial conditioning of an animal, but one that is available throughout the useful employment of a working dog, to elicit a concentration for new sensory discrimination, or a slightly new complex situation.

The word "Encouragement" is intended to represent a preliminary phase of the third word "Reward" in the same manner that "Warning" denotes a preliminary phase of the fifth word "Punishment". It says to the animal, "That's right, keep it up, you are getting there but haven't fully accomplished the task yet." In form, the encouragement message is a diminutive form of the reward message.

The "Reward" signal is a representation of the pleasurable interaction between the dog and his trainer. It is to be developed by the association between the dog and his trainer during petting, feeding and playing. It is to be used by telemetry as the "payoff" to the animal for a task well done.

The "Warning" message represents the graded displeasure of the trainer's evaluation of the dog's activity. His warning can be likened to the growl of the dog prior to attack, where I think the message conveyed is unmistakably clear to the human.

Just as the growl might be followed by an attack involving injury, the "Punishment" command is restricted to only those extremely rare cases where the dog's behavior is unacceptable in terms of the trainer's objectives. The common form of the electric shocking collar is a good representation of the form that the punishment command might take. We must remember that

electric shock used in this way is an unforgettable experience to the animal, one which is permanently imprinted and related to his behavior at the instant the shock was received. The importance of the well developed warning message is that it tends to all but eliminate the actual punishment once the dog has coupled the warning with the subsequent shock.

The function of the subroutine, or operative vocabulary, should be obvious. Once a procedure is learned through the conditioning vocabulary, it becomes economical to identify it with a single message, and each message then is stored in both the dog's memory and the instrumentation so that it may be utilized at future times with the appropriate result.

Physiological Feedback

Now let us turn our attention to the ways in which the dog communicates with its trainer. These, of course, are well established in an experienced trainer and they do convey a great deal of information about the condition and alertness of the animal--his sickness or health, his mood, his alertness to possible danger and the type of threat he feels. The language of the scent hounds is conveyed over long distances and here again the trainer knows when the scent is fresh or old by the excitement conveyed in the baying of the hounds, and he also knows when the hounds' language changes from the baying on the trail to the barking that signifies the quarry is at bay. He knows his animals' voices individually and he can tell when one is injured or experiencing difficulty in heavy brush by the shift from the bay to a whine. But now suppose that we impose silence on our working dog and ask that instrumentation provide a coded communication from the animal to the trainer out of sight and hearing. We believe that the most effective form of communication in this case is to read the psycho-physiological responses of the animal directly and to seek to directly instrument the natural transient changes of the physiology--to interpret these in such a way that the message is single valued and unmistakable. There is no doubt that the dog does experience identifiable moods during the tracking and acquisition of natural prey. It seems likely from our experience with wild animals that it will be possible to sense and identify these physiological reactions, which are in themselves processed information that the animal perceives, modified by the animal's interpretation of its value and validity in terms of the task he has been trained to perform. Ideally the instrumentation necessary for

this communication coding will operate without the need for surgery and, in effect, be no more difficult to apply to the animal's body than the buckling of a collar around its neck. Most of our initial work has been done by implanting minute thermistor sensors in the facia or connective tissue between the hide and the muscle. We have been utilizing recently a sensor which measures heat flux directly rather than temperature and we feel that this technique will eliminate the need for the small skin incision. Our preliminary work has led us to believe that the rapid change in temperature is correlated with alerting stimuli. We are therefore not particularly interested in the surface body temperature as such in a working animal. Our preliminary experience suggests that transients occur at rates on the order of one-tenth degree per second, and perhaps faster. The flow of blood in the vascular system of the skin is under direct nervous control and hence we expect that significant changes can occur in heat flow from the body to an external heat sink at rather rapid rates. For our purposes long term transients such as the increase in body temperature during activity, are not directly related to our sensing objectives.

System Integration and Summary

I have to this point considered some of the details of the communication coding. Let me briefly now describe some of the instrumentation which we will apply to this study. Over the past 10 years the Sensory Systems Laboratory has been engaged in the development of research techniques applicable to the study of free-roaming animals. This has resulted in the development of reliable tracking systems for the study of territoriality and ranging in wild animals. Transmitters are available which, with strip line antenna techniques, allow the generation of tracking signals at useful ranges of up to 100 miles. Under nominal temperature conditions, approximately two pounds of batteries will operate these transmitters for periods of up to one year. Our receiving antennas allow us two modes of detection--a sensitive mono-directional receiving system for long range work, and a second antenna based on interferometer principles which provides precise bearing data at closer ranges. We have been able to undertake telemetry of a number of physiological responses in free-roaming wild animals, to include multi-channel temperatures, heart rate, electrical potentials, diving

depth, swimming speed and blood pressure. We will employ a small computer plotting board system, manufactured by Hewlett-Packard, as a signal analysis and display facility. We sincerely intend that this program will result in a significant advance in the utilization of animals and their natural sensory acuity in a productive, humane and useful program for the U. S. Air Force.

Towards a Training Technology for the
Military Working Dog

Robert Berryman
Themis Project Manager

University of Mississippi

From the earliest moments of human history, dogs have been selected (and bred selectively) for various talents that complement man's own, whether in superior sensory capacity--as in scenting or hearing---greater speed, or other special characteristics. Yet our ability to take advantage of the dog's potential is never any better than the training techniques we use to bring his behavior under human control so that it may be put to human uses. Now, the various factors important in the training process have been studied extensively by psychologists interested in how learning occurs. The principles they have established in carefully controlled laboratory work are bringing about some revolutionary changes in our understanding of the problems of human education. Since the laws of learning are very broad in scope it is interesting for us to examine here some of the implications of present-day learning theory for the improvement of training techniques for military dogs.

For a long time, our understanding of the learning process was so fragmentary and incomplete that it could not form the basis for rational applications. However, with the last three decades, largely due to the pioneering work for Professor B. F. Skinner and his school, we are beginning to see the emergence of a true technology of education in which

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principles derived from controlled experiments are put to use in the solution of practical problems. More generally, we may think of "behavioral" engineering which uses the principles of behavior in the production of a given performance, in the same way as we speak of chemical engineering when chemical principles are used in the production of a given compound or substance.

Granted, as most psychologist do, that our theoretical grasp of the learning process is sufficient basis for a reasonably efficient behavioral engineering, what are the implications for us, who are, in one way or another concerned with the production of certain performances in the military working dog?

To begin with, we must recall that the discovery of a principle does not mean the same thing as the invention of a technology based upon it. Often technology lags years or centuries behind. It is not an exaggeration to say that all of the essential principles involved in the Apollo moonlanding of 1969 were known in the 19th century, if not earlier.

This is very much the case in behavioral engineering. Workers in the field of programmed learning have often found it singularly difficult to apply well-established principles. Apart from this problem there are at least two others that should be mentioned in passing: The dog has been largely neglected as a subject by modern behavior theory, in spite of the fact that there is no dearth of studies on other animal subjects, such as primates, birds, cats and others. Then, too, learning

theorists have sought principles that are true no matter what the species membership of the subject, and therefore tended to neglect the unique behaviors characteristic of a given species. The latter study has been the preoccupation of the ethnologists who are interested in examining the peculiar relations between an organism's behavior and the variables present with the environment of its own special environmental niche.

All of these considerations show the need for and importance of a conference such as this one, where contact among the persons working on various aspects of a common problem provides for a great deal of corrective feedback and thus prevents us from drifting too far from the main track.

I should like to take advantage of the circumstances by (1) describing some basic ideas of the analysis of behavior (2) showing how some of these ideas are combined in the design of laboratory procedure for dogs, (3) suggest extensions to field conditions.

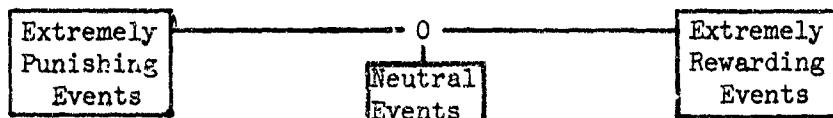
In order to obtain the type of feedback that was mentioned I would appreciate your comments after my presentation. Particularly, I should be interested in knowing how many of the basic principles do you make use of in your own work? What other principles are used? What other related problems are there?

A very important concept of learning theory is that we can best understand behavior by its consequences, or in other terms by finding out how the behavior changes a given situation. Generally, some types

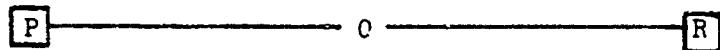
of consequences make it likely that the behavior that produced them will be repeated in the future, while others have the opposite effect and tend to eliminate the behavior that produced them. Obviously, in addition to the "significant" changes that tend to make the behavior that produced them more or less likely in the future, there are other "neutral" or unimportant changes which do not have any influence on the future course of behavior. And finally, the behavior may simply not produce any change at all.

The "significant" changes are the kinds of events we ordinarily think of as rewards and punishments, but we must be careful with these terms. A significant event, such as food or a shock may either increase or decrease the future likelihood of a given bit of behavior, depending upon its relation to that behavior.

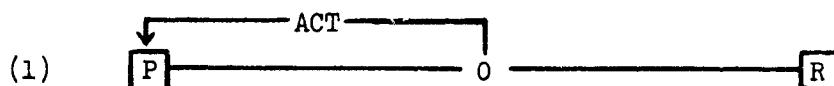
To make clear the concepts that we are discussing, let us diagram the possible relations between these significant events and the behavior that produces them. Imagine at the left of a scale extremely punishing events. As we move towards the right, these events become less and less punishing and finally neutral or indifferent at the zero point. Next, as we continue moving to the right on the other side of the zero point, events become progressively more rewarding, and finally extremely so.



Next, after abbreviating our diagram to



where P stands for punishing, 0 for neutral, and R for rewarding events, we are in a position to ask a fundamental question: If the dog's act produces a changed situation, what is the nature of direction of the change? In brief, we have the situation immediately before the act occurs and the situation immediately after. Let us assume that the first situation is neutral and that the act is punished. We then have

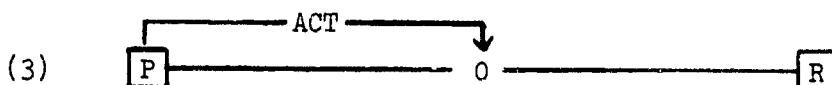


with the arrow indicating that an initially neutral situation is transformed into a punishing one as a consequence of the act, or, in the act,



or behavior is producing a rewarding set of circumstances.

In addition, there are two more major cases, in which the initial situation is not neutral;



where the act eliminates a set of punishing conditions, and finally;



where the act eliminates rewarding events from the situation, as, for example, when a child is sent to bed without supper as a consequence of misbehaving.

Now, it would seem obvious in intuitive terms, and this is borne out by Experimentation, that procedures (2) and (3) should result in the strengthening of the act and an increase in the chances that it would be repeated in the future; while procedures (1) and (4) should weaken the act and make it less likely to reoccur.

In essence, then, by manipulating the possible consequences, we have two ways of strengthening and two ways of weakening behavior in the animal's repertoire. This is the basic clue on how to maintain and increase the strength of desirable behavior while eliminating and weakening undesirable behavior. Thus, in summary, we may accentuate the positive by

- (1) allowing the positive behavior to produce rewards, or
- (2) to remove punishing conditions, while we can eliminate the negative by
 - (1) punishing the undesired behavior, or
 - (2) removing rewards from the situation when undesired types of behavior occur.

Note the crucial idea that behavior can be weakened or strengthened by appropriately manipulating its consequences. Yet, for the consequences to modify behavior the behavior itself must first occur. This means that we can only reward or punish behavior which already exists in the subject's repertoire. While this is quite true, it does not imply that we will therefore never be able to create any truly new behavior. Actually, the animal's behavior is naturally variable; by strengthening those acts which are closer to the desired performance,

and weakening those which are less adequate, we can shape up almost any final desired performance, somewhat as the sculptor models clay.

In applying these notions to problems of dog training, our first experiments dealt with the relative usefulness of food and water as rewards. We were able to show that water functions as an extremely effective reward even at very moderate thirst levels. This is a promising finding since water delivery systems are simpler and more reliable than those for food delivery.

A study was also carried out on the possibility of using radio-controlled shock collars as a means of presenting punishing stimuli.

The results were far short of satisfactory: Shocks appeared highly variable in intensity and it seems unlikely that a simple and reliable shock system of this type can be developed without implanting electrodes in the dog's skin--a procedure which has a number of obvious drawbacks.

As an example of typical procedures used in our laboratory, I shall describe in some detail an experiment on controlled locomotion. Basically, we are interested in studying the dog's sensory capacity--the keenness of his senses of sight, hearing and smell; particularly. To make this kind of determination we must provide the dog with responses that he can use to signal the presence or absence of a given stimulus, or to indicate which of two stimuli is present, and so forth. We have found that an effective way of doing this is to have the dog locomote to different places depending upon the stimuli. When he behaves according to the rules that we have established, he receives a water reward on arriving at the designated places.

In a current procedure we use three stations located at the apices of an equilateral triangle. In front of each station is a large treadle which the dog steps on to activate. Two stations have provision for presenting a light and a tone as distinctive stimuli, and also solenoid operated valves which present the water rewards. The third station serves to set up the stimuli on the other two stations. When the dog steps on it, the light and tone appear at either one or the other of the two stations. If the dog runs to the station with the light and tone, he receives a water reward when he steps on the treadle. If he goes to the wrong station, the trial is ended without reward and he must go back to the third station and step on the treadle there to set up the stimuli again.

Training is completely automatic. The dog is deprived of water for approximately 24 hours and then placed in the room containing the stations. The stations themselves are placed close together. In the course of moving about, the dog will step on the treadles and receive occasional rewards. During the first session the sequence of stepping on the third station treadle and then going to one of the other stations, emerges without the intervention of the experimenter. After about 200 trials the animals work at near 100 percent levels, in the case of the light-tone discrimination.

We are using this procedure to study visual acuity. This is being done by training dogs to go to the station which shows a broken rather

than a complete circle. After the performance is acquired the stations are drawn farther and farther apart until the dog is showing a chance level of performance. Knowing the distance of the station and the gap size in the broken circle it is then possible to calculate visual acuity.

Finally, these controlled locomotion techniques can be adapted to the development of a patrol dog that "checks in" in a predetermined sequence at strategical placed stations.

SURGICAL REHABILITATION OF THE DYSPLASTIC DOG

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Hip Dysplasia in dogs is a hereditary disease common to several large breeds (German Shepard, St. Bernard, Labrador Retriever, Great Pyrenees, Old English Sheepdog, and others). The inheritance is reported to be neither dominant nor recessive, but polygenic. Characteristic changes in the dysplastic coxofemoral joint occur with varying onset and severity and may include (1) a shallow acetabulum, (2) a flattened femoral head, (3) coxofemoral luxation or subluxation, and (4) degenerative joint disease. The wide variety of acetabular and femoral head changes are thought to result from joint laxity.² The deformities of the acetabulum and femoral head are not present at birth, but have been considered to develop subsequent to the stress of weight bearing.³ Although a cause and effect relationship has not been proven the relationship of the pectineus muscle is being investigated as a possible factor in the development of canine hip dysplasia.^{4,5}

In the past few surgical procedures have been available for treating the dysplastic dog. One is an acetabuloplasty described by Brinker,⁶ however, its use is contraindicated in cases with marked deformity of the femoral head and acetabulum. For best results it should be used in dogs 4-9 months of age. Other forms of acetabuloplastic procedures have been used wherein synthetic materials or bone grafts have been placed over the dorsal brim of the acetabulum. Another procedure is the pelvic osteotomy⁷ which has been modified for the dog and in principle is the same as the innominate osteotomy described by Salter for use in children. The pelvic osteotomy is reported⁷ to be most effective in dogs between 6 and 10 months of age with early radiographic and clinical signs of hip dysplasia. An additional procedure is the femoral head and neck ostectomy which should be used as a last resort when all other procedures have failed or could not be used.

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The purpose of this paper is to describe a new surgical procedure which has proven to be very effective in rehabilitating clinically dysplastic dogs. The preliminary study consists of 25 dogs from 10 breeds that were admitted to the Kansas State University small animal hospital. (Tables 1, 2a, 2b)

Surgical Procedures:

All dogs were given atropine sulfate subcutaneously prior to general anesthesia. Induction of anesthesia was done by the intravenous administration of Thiamyl Sodium[†]. Anesthesia was maintained by either methoxyflurane⁺⁺ or fluothane⁺⁺⁺ and oxygen through an endotracheal catheter connected to a semiclosed system. Fluids were administered intravenously to all animals during surgery.

All dogs were positioned in dorsal recumbancy. The entire medial aspect of each thigh, extending from the stifle to and across the pelvic midline was prepared in a routine manner for aseptic surgery. When the dog was placed on the surgery table the rear legs were secured in place so the femurs were perpendicular to the midline. Positioning the rear legs in this way facilitates identification of the pectineus muscles and draping of the surgical site. Drapes were placed on each leg anterior and posterior to the pectineus muscle. Drapes were also placed across the supracondylar region at the distal end of each femur. All drapes were secured in place with towel clamps. A large shroud was then placed over the dog with the surgical site exposed through the shroud opening.

The pectineus muscle originates from the ventral aspect of the acetabulum and inserts on the distal posterior surface of the femur. The tendon of insertion is long, thin, and wide. The surgery site is identified by palpating the distal end of the pectineus muscle where it is crossed obliquely by the posterior border of the caudal belly of the sartorius muscle. Approximately 5-8mm. proximal from where the sartorius crosses the pectineus a muscular branch of the cranial femoral artery and vein crossed the pectineus muscle. Pulsations of the muscular branch could be palpated in most dogs. A 2 inch skin incision was made over the pectineus muscle and tendon extending distally from the above mentioned landmark. Hemostasis was maintained by ligation or electrocautery. The subcutaneous tissue was bluntly dissected to expose the posterior border

[†]Surital, Parke-Davis & Co., Detroit, Mich.

⁺⁺Metofane, Pitman-Moore, Inc. Fort Washington, Pa.

⁺⁺⁺Fluothane, Ayerst Laboratories, New York, N.Y.

of the caudal belly of the sartorius muscle and the muscular branch of the cranial femoral artery and vein. The fascia along the posterior border of the sartorius muscle was incised for approximately 1 inch where it crossed the pectineus tendon. That part of the sartorius muscle was reflected anteriorly and the pectineus tendon identified. The femoral artery and vein are adjacent to and partially cover the pectineus tendon and should be retracted anteriorly. The pectineus tendon was then freed of surrounding fascia. A right angle forcep was passed around the anterior surface of the tendon and under its lateral border. By lifting up on the forcep the tendon was brought into clear view and transected (Figure 1). Following tenotomy, the pectineus muscle retracts proximally. After transection of the tendon, the area should be palpated to make sure all of the tendon was severed. If any part of the tendon should be missed it must be identified and severed for the surgery to be successful. After the tenotomy the pectineus muscle was digitally pushed further proximal.

The tissue space created by the tenotomy could not be sutured closed because of the major vessels in the area. Subcutaneous tissue and skin were closed by routine methods. Skin sutures were removed on the 10th post-operative day.

Pectineus tenotomies have also been done at the tendon of origin and at the distal end of the tendon of insertion (Figure 1). So far the results have been equally effective regardless of which of the above areas the tenotomy was done. Tenotomies at the tendon of origin were done close to the pectineus muscle fibers. A tenotomy done at this location will result in the pectineus muscle retracting distally. Special care was taken to avoid major blood vessels in the area and branches of the obturator nerve. At the distal end of the femur the pectineus tendon of insertion lies immediately under the sartorius muscle. To expose the tendon the muscle fibers were bluntly separated. Special care was taken to avoid major blood vessels in the area.

The tenotomy technique described in detail above at the proximal part of the pectineus tendon of insertion is the one we recommend because in this area the tendon is easy to locate, identify, and transect and the procedure is less hazardous. Occasionally a seroma will develop at the surgical site. If this occurs the skin over the seroma should be prepared for aseptic aspiration of its contents and drained.

Regardless of whether the tenotomy is done at the proximal or distal region of the tendon of insertion or the tendon of origin the entire tendon must be transected for the surgery to be successful.

Results:

The dogs in this study were from 4 to 120 months of age and weighed from 40 to 180 lbs. at the time of surgery. (Tables 2a and 2b). The sex ratio was almost equal with 13 male and 12 female dogs. Of the 25 dogs, 24% (6 of 25) were considered to be in fair and 76% (19 of 25) in good general health. Dogs were placed in the category of fair general health because of having nutritional, cardiac, or other orthopedic problems at the time of surgery. Dog #8 (Table 2a) was the only one which did not have a pre-surgical or progressive lameness. This dog had a peculiar stiffness of the rear legs which was apparent only when running. The dogs were from 4 to 60 months of age with an average age of 11.7 months when the first radiographic diagnosis of hip dysplasia was made. Radiographs at the time of surgery revealed osteoarthritic changes in 60% (15 of 25) of the dogs. Palpation of the coxofemoral articulation revealed moderate to severe laxity of the joint in all dogs. This joint laxity was present in all dogs under surgical anesthesia and in several dogs before anesthesia. Luxation or varying degrees of subluxation were observed radiographically in all dogs. All grades of hip dysplasia were represented within these 25 dogs.

Twenty four of the dogs had bilateral hip dysplasia. One dog (No. 21) had unilateral hip dysplasia. Bilateral tenotomies were done in all dogs. The post-operative results for these dogs were graded as good (functional use of the leg without any pain), fair (functional use of the leg with intermittent pain), and poor (little or no improvement following surgery) (Table #3). From the current follow-up data good results have been obtained in 92% (23 of 25) of the dogs operated on.

Discussion:

This surgical procedure is not a cure for hip dysplasia. It is intended to relieve pain and rehabilitate the clinically dysplastic dog regardless of whether it is a family pet or a working dog. To date it has proven effective in dogs with hip dysplasia too far advanced for either the acetabuloplasty or the pelvic osteotomy to be effective. In the past the dog with advanced hip dysplasia had to be treated medically, which was not completely satisfactory on a long term basis, or be subjected to a femoral head and neck osteectomy. From our current studies it would appear that excision arthroplasty may not be necessary for rehabilitating the dysplastic dog. At this time it is impossible to know how long these dogs will continue to remain totally rehabilitated at such a high success rate. In all cases the owners are instructed not to use their dog for breeding purposes. In some instances owner's request a vasectomy, orchiectomy, or ovariohysterectomy be done at the time of the tenotomy.

The dogs in this study were of various ages and weights and all grades of hip dysplasia were represented. In all of the dogs, except No. 17, clinical improvement was observed within 24 to 48 hours following surgery. Clinical improvement was observed in dog No. 17 on the 4th post-operative day. This dog was in extreme pain when admitted to the hospital. When discharged on the 5th post-operative day the animal walked out of the hospital but was noticeably lame in the right rear leg. To date the right rear leg has revealed very little improvement. The left rear leg was much improved but the dog continues to have intermittent pain in this leg. Dog No. 21 revealed marked clinical improvement within 24 hours following surgery. On the 12th post-operative day the animal was used for hunting and had no lameness. It was not until the hunting season was over and the dog was confined to a kennel that lameness was observed.

Follow-up radiographs are taken on these dogs every 6 months. Dogs which had mild to moderate radiographic evidence of hip dysplasia at the time of surgery revealed progressive radiographic changes in the follow-up studies. However these dogs were not lame or did not have any pain at the time of the follow-up examination. Some of these dogs were in severe pain, having difficulty walking, and on occasion showing disposition changes prior to surgery. Following surgery these problems were corrected in all animals except dogs 17 and 21 which were mentioned in the above discussion. After laying on cold concrete, on the cold ground or in snow some of the St. Bernards have been observed to have a stiff gait when they get up and start to walk. However, after a few steps the stiffness disappears. At no time have they appeared to be in pain.

The exact reason for such rapid and marked improvement is still uncertain. Further studies are being conducted to clarify this point. A major reason for the clinical improvement in these dogs is thought to be due to a reduction in tension within the coxofemoral articulation and especially on the joint capsule. All of these dogs had limited abduction and extension of the rear legs prior to surgery. When the tenotomy was completed, an immediate increase in the degree of abduction and extension of the rear legs occurred. Generally this is in direct proportion to the severity of hip dysplasia in a given animal.

Although the long term effects of this surgical procedure are yet to be determined, current data is very encouraging. Dog No. 6 was the first to be operated on and it is now 26 months since the surgery. This dog currently weighs 95lbs. and although there have been progressive radiographic changes in the acetabuli and head and neck of each femur the dog is capable of hunting a full day, is free of pain and has no lameness.

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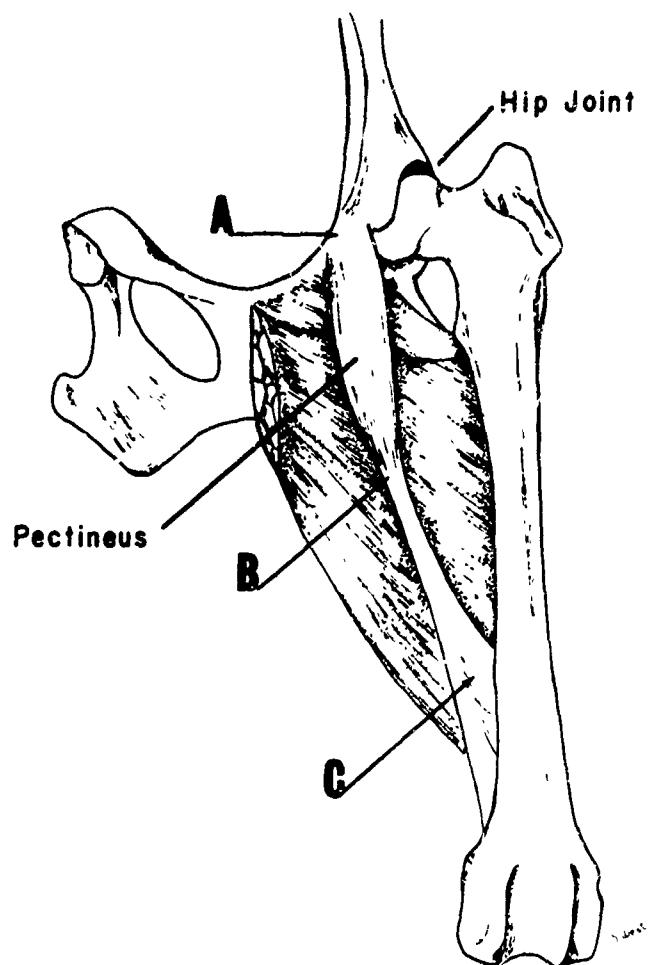


Fig. 1. Drawing illustrates the hip joint, femur, tendon of origin (A), proximal end of the tendon of insertion (B), and distal end of the tendon of insertion (C) of the pectineus muscle in the dog.

| <u>BREED</u> | <u>NUMBER OF DOGS</u> |
|------------------------------|-----------------------|
| Old English Sheepdog (OES) | 4 |
| Labrador Retriever (L. Ret.) | 4 |
| Great Dane (Gr. D.) | 1 |
| Irish Setter (Ir. Set.) | 1 |
| German Shepherd (G. Shep.) | 5 |
| English Setter (Eng. Set.) | 1 |
| Malmute (Mal.) | 1 |
| English Pointer (Eng. Pt.) | 1 |
| Great Pyrennes (Gr. Pyr.) | 2 |
| St. Bernard (St. B.) | 5 |
| TOTAL | 25 |

Table 1. Summary of breeds and numbers of dogs operated on in the initial clinical study.

| No. | Breed | Sex | Current Age (mo.) | Surgery Wt. lbs. | Age At Surgery (mo.) | General Health | Pre-Surg. Lameness Duration (mo.) | Progressive Lameness | Age At X-Ray Diag (mo.) | Pre-Surg. Osteoarthritis | Joint Laxity |
|-----|---------|-----|-------------------|------------------|----------------------|----------------|-----------------------------------|----------------------|-------------------------|--------------------------|--------------|
| 1 | St. B. | M | 38 | 180 | 24 | Good | 15 | + | 9 | + | + |
| 2 | St. B. | F | 15 | 61 | 7 | Good | 4 | + | 7 | - | + |
| 3 | St. B. | F | 20 | 100 | 8 | Good | 1 | + | 8 | - | + |
| 4 | St. B. | F | 12 | 100 | 8 | Good | 6 | + | 8 | - | + |
| 5 | St. B. | M | 10 | 90 | 6 | Good | 2 | + | 6 | - | + |
| 6 | L. Ret. | M | 32 | 62 | 5.5 | Good | 1 | + | 5.5 | - | + |
| 7 | L. Ret. | F | 11 | 67 | 6 | Good | 1.5 | + | 6 | + | + |
| 8 | L. Ret. | F | 20 | 48 | 14 | Good | -- | - | 9 | - | + |
| 9 | L. Ret. | M | 16 | 67 | 14 | Good | 2 | + | 12 | + | + |
| 10 | O.E.S. | M | 14 | 58 | 12 | Good | 6 | + | 6 | - | + |
| 11 | O.E.S. | F | 9 | 40 | 7 | Good | 1 | + | 6 | + | + |
| 12 | O.E.S. | F | 60 | 60 | 8 | Fair | 1.5 | + | 7 | + | + |
| 13 | O.E.S. | M | 14 | 60 | 12 | Good | 6 | + | 11 | - | + |

Table 2a. Specific clinical data on dogs in the initial study. See Table 1 for identification of breed abbreviations.

| No. | Breed | Sex | Current Age (mo.) | Surgery Wt. lbs. | Age At Surgery (mo.) | General Health | Pre-Surg. Lameness Duration (mo.) | Progressive Lameness | Age At X-Ray (mo.) | Pre-Surg. Osteoarthritis Diag. (mo.) | Joint Laxity |
|-----|----------|-----|-------------------|------------------|----------------------|----------------|-----------------------------------|----------------------|--------------------|--------------------------------------|--------------|
| 14 | G.Shev. | M | 25 | 75 | 21 | Fair | 1 | + | 16 | + | + |
| 15 | G.Shev. | F | 15 | 58 | 12 | Good | 8 | + | 12 | + | + |
| 16 | G.Shev. | F | 23 | 80 | 12 | Good | 5 | + | 10 | + | + |
| 17 | G.Shev. | F | 123 | 60 | 120 | Fair | 96 | + | 24 | + | + |
| 18 | G.Shev. | F | 8 | 46 | 6 | Fair | 1 | + | 6 | + | + |
| 19 | G.Pyr. | M | 14 | 98 | 9 | Fair | 3 | + | 9 | - | + |
| 20 | G.Pyr. | F | 17 | 65 | 12 | Fair | 2 | + | 12 | + | + |
| 21 | Eng.Pt. | M | 22 | 70 | 17 | Good | 12 | + | 17 | + | + |
| 22 | Mal. | M | 10 | 48 | 4 | Good | 2 | + | 4 | + | + |
| 23 | Eng.Set. | M | 63 | 51 | 60 | Good | 24 | + | 60 | + | + |
| 24 | Gr.D. | M | 9 | 53 | 7 | Good | 2 | + | 5 | - | + |
| 25 | Ir.Set. | M | 20 | 85 | 18 | Good | 3 | + | 18 | + | + |

Table 2b. Continuation of Table 2a.

| POST-OPERATIVE RESULTS* (months) | | | | | | |
|-------------------------------------|------------|---------------|------|-------|-------|-------|
| No. | Breed | 1-6 | 6-12 | 12-18 | 18-24 | 24-30 |
| 1 | St. B. | Good | Good | Good | | |
| 2 | St. B. | Good | Good | | | |
| 3 | St. B. | Good | Good | | | |
| 4 | St. L. | Good | | | | |
| 5 | St. B. | Good | | | | |
| 6 | Lab. Ret. | Good | Good | Good | Good | Good |
| 7 | Lab. Ret. | Good | | | | |
| 8 | Lab. Ret. | Good | Good | | | |
| 9 | Lab. Ret. | Good | | | | |
| 10 | O.E.S. | Good | | | | |
| 11 | O.E.S. | Good | | | | |
| 12 | O.E.S. | Good | | | | |
| 13 | O.E.S. | Good | | | | |
| 14 | Ger. Shep. | Good | | | | |
| 15 | Ger. Shep. | Good | | | | |
| 16 | Ger. Shep. | Good | Good | | | |
| 17 | Ger. Shep. | L-Fair R-Poor | | | | |
| 18 | Ger. Shep. | Good | | | | |
| 19 | Gr. Pyr. | Good | | | | |
| 20 | Gr. Pyr. | Good | | | | |
| 21 | Eng. Pt. | Fair | Good | | | |
| 22 | Mal. | Good | | | | |
| 23 | Eng. Set. | Good | | | | |
| 24 | Gr. D. | Good | | | | |
| 25 | Ir. Set. | Good | | | | |

* Good - Functional use of leg without pain.
Fair - functional use of leg with intermittent pain.
Poor - Little or no improvement.

Table 3. Postoperative results obtained as of January 1970. See Table 1 for identification of breed abbreviations.

Discussion (Dr. Wallace)

How long does it take for surgery and how long for the dog to be back on his feet?

--After the dog has been anesthetized and prepped, we are talking about both rear legs, from the time that you make the incision until you sew it back up on the opposite leg, you are talking about 20 minutes maximum. They are usually back on their feet in 24 to 48 hours. You can operate in the morning and send him home that afternoon.

If we had a dog that we brought in to you with a doctor, would you operate on him and demonstrate to him at the same time?

--Yes.

Would you say this surgery is a prophylactic measure to be used in projecting progression of dysplasia such as grade I?

--I don't believe you will stop the progressive changes in the skeletal system itself. As far as the acetabulum and the femoral head are concerned, I'm convinced that when we see a dog already showing dysplasia, and we've seen radiographic progressive changes, I don't think you're going to stop it there. I am concerned with the standpoint of alleviating the pain and discomfort the dog is having and to put him back into a working situation.

So that what you are saying is that radiographically the dog looks worse but performs better.

--Yes.

How many have you done at this four month age that actually showed improvement?

--In this particular group here we have about two that have been done at four months. One was that malmute and the other was this severe German shepherd.

How do you account for the fact that they don't have any pain after surgery?

--I can't prove this, it's simply a thought, and if anybody here has any thoughts on it I'd certainly appreciate hearing that too. I think that the pain these dogs are getting is coming from pressure changes, because we eliminate that pressure when we cut this tendon.

One thing we have noted here at Lackland is the distinct lack of correlation between severe hip dysplasia in the radiographs and clinical symptoms.

--There really isn't any correlation.

NEUROMUSCULAR DISEASE: A POTENTIAL FACTOR IN
THE ETIOLOGY OF CANINE HIP DYSPLASIA

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Canine hip dysplasia has been reviewed in the literature (4, 5, 6) and only a few points will be considered here as an introduction to the problem, and the line of investigation being pursued in our laboratory.

Hip dysplasia in dogs is a hereditary disease of the hip joint in which there is a faulty development of the joint. In the normal hip, the acetabulum should be semicircular with sufficient depth to accomodate the head of the femur. In turn, the head of the femur should be smooth, round and fit well into the acetabulum (Fig. 1). The resultant articulation should permit normal function of the joint such that movement of the femur does not result in deviations or changes in the position of the femoral head within the acetabulum. In the dysplastic hip, the acetabulum is less concave and more shallow than normal. The head of the femur is flattened and does not fit well in the acetabulum (Fig. 2). The resultant malformation of the hip joint results in considerable displacement of the femoral head with movement of the femur. As a consequence of this movement various degrees of osteoarthritis may result, and in severe cases luxation of the femoral head may occur. The end result is an impairment of locomotion and hence the ability of a dog to work is compromised.

The disease is common to many breeds of large body size, and the incidence of the disease may be as high as 50 to 80 percent. The disease cannot be diagnosed at birth. In severe cases radiographic diagnoses may be possible at three to five months of age, and not until 12 months in milder cases. Even at 12 months of age, it is estimated that only 70 percent of the dogs which will eventually become dysplastic can be detected. The high incidence of the disease and wide range of ages when radiographic examination permits diagnosis presents a serious problem in the early detection of hip dysplastic dogs. Early detection of dysplasia in working dogs is important to avoid the loss of time and investment in their training. For example, this is of practical significance in the German Shepherd dog when one considers the time and expense involved in their training as Sentry Dogs for the Armed Services and seeing eye dogs for the blind.

Many aspects of the disease have been studied and described; however, the precise cause is unknown. There appears to be a general consensus that the wide variety of bone changes observed in the acetabulum and femur are preceded by looseness of the joint (joint laxity) and that these changes are a consequence of joint laxity. In 1968, a technique was developed to judge joint laxity in puppies four to eight weeks of age, and it was proposed that this technique could detect hip dysplasia in puppies at this age (1). In the development of this technique it was observed that abduction of the hind legs was restricted in puppies judged to be dysplastic. Further, the restricted abduction appeared to be due to the pectineus muscle, an adductor muscle, since severing the tendon of insertion was accompanied by full abduction of the legs. Based on these observations it was suggested that the pectineus muscle by shortening or spasm could create abnormal forces within the hip joint of puppies and affect the formation of the hip joint.

In view of the suggestion of muscle involvement in the etiology of canine hip dysplasia, an initial study was undertaken to determine if abnormalities of this muscle exist. The results of this

study, which will be subsequently described, have revealed a developmental myopathy in the pectineus muscles of German Shepherd and mongrel dogs (2,3).

The pectineus muscle is a relatively small muscle weighing about three grams per 10 kilograms of body weight. It originates from the prepubic tendon and iliopectineal eminence and inserts on the medial and posterior aspect of the distal femur (Fig. 3).

Muscles of the body are composed of a rather heterogeneous group of cells called muscle fibers. By use of histochemical techniques, two principle types of muscle fibers can be distinguished and they are referred to as Type I and Type II muscle fibers. Type I fibers are biochemically suited to derive adenosine triphosphate (ATP) as a source of energy for contraction by oxidative phosphorylation, while Type II fibers are suited to derive ATP for contraction by substrate phosphorylation via anaerobic glycolysis. In addition to differences in their metabolism for the generation of ATP, these fibers differ in their utilization of ATP for contraction in that there are quantitative and qualitative differences in their myosin-ATPase activities (Fig. 4). These differences in biochemical properties of muscle fiber types are also associated with physiological differences. Muscles composed primarily of Type II fibers contract faster and develop greater tensions than muscles composed primarily of Type I muscle fibers (Fig. 4).

A description of the postnatal growth and differentiation of pectineus muscle fibers should be considered for a better understanding of the myopathy. At birth and shortly thereafter the pectineus muscle is composed primarily of Type II muscle fibers as defined by their myosin-ATPase reactions. With age there are two changes which occur: (a) there is an increase in muscle fiber size, and (b) there is an increase in the percentage of Type I fibers (Fig. 5). Since there is no evidence for an increase in the number of fibers it appears that the increase in percentage of Type I fibers is due to a transformation of Type II fibers into Type I fibers.

Abnormal pectineus muscles were observed in German Shepherd and mongrel puppies 28 to 118 days of age. The abnormality or lesion was characterized by extreme variations in muscle fiber size. The smallest fibers were predominantly Type II fibers while the largest fibers were predominantly Type I fibers (Fig. 6). The lesion varied from being very focal, involving less than 25 percent of the cross-sectional area of the muscle, to very diffuse, involving more than 75 percent of the muscle. The differences between affected and unaffected areas of the muscle are marked (Fig. 7). In addition to the variations in muscle fiber size, the affected areas tended to have a greater percentage of Type II fibers than the unaffected areas.

Based on our knowledge of the growth and differentiation of this muscle, the changes observed in the abnormal muscles are characterized by: (a) a delayed growth of Type II muscle fibers, and (b) a delayed differentiation of Type II muscle fibers into Type I muscle fibers. To date this lesion has not been observed in other muscles of the hip.

In general, pathological changes in muscle permit classification of a disease as myogenic where there is a defect in the muscle cell itself, or as neurogenic where the muscle changes are secondary to some defect in the nerve supply to the muscle. In many ways, the lesion observed is suggestive of a neurogenic disease; however, examinations of nerve and spinal cord have not revealed pathological changes to establish this point. Studies indicate that the growth of muscle fibers and the transformation of Type II fibers into Type I fibers is dependent on the motor nerve innervation of the fibers, and it is proposed that the nerve exerts some trophic influence that directs these changes. It is possible that the lesion seen in the pectineus muscle of the dog represents an abnormality in trophic influences of the nerve on the muscle fibers.

The effect of the lesion on the gross weight of the muscle varies; however, in cases of diffuse involvement there is a tendency for the relative weight of the pectineus muscle to be smaller (Fig. 8).

To date, 86 dogs have been examined between 28 and 118 days of age. The lesion has been observed in German Shepherds and mongrels but not in Greyhounds (Table 1). It is of considerable interest that the lesion has not been found in Greyhounds since this breed is relatively free of hip dysplasia. While this observation does not prove that there is a relationship between the incidence of hip dysplasia and the muscle lesion, it is an observation that would be consistent with such a relationship.

In view of the relationship between muscle fiber types and the physiological properties of contraction, it would be anticipated that the lesion would result in alterations in the contraction properties of the pectineus muscle. A series of physiological experiments with normal and abnormal pectineus muscles is currently being conducted, and the results indicate that there is an alteration in muscle function associated with the disease. The muscle lesion results in slower speeds of contraction and the development of smaller twitch tensions (Fig. 9), and the magnitude of these alterations appears to be related to the extent of involvement.

With regard to the possible relationship of canine hip dysplasia and the muscle lesion observed, it is known that muscle function is an important factor in determining the final shape of the skeleton. Factors which affect the modeling or shape of bone have a more pronounced effect if they occur during fetal or neonatal growth since the capacity of bone for modeling decreases with age. The finding of a muscle lesion in the pectineus muscles of dogs in which there is a high incidence of hip dysplasia during a period when bone is highly susceptible to modeling forces provides a tenable thesis for muscle dysfunction as an etiological factor in hip dysplasia. Such a cause-effect relationship has not been proven and requires further investigation. Current efforts are focused in this direction. Further, it has not been established that the muscle abnormality is inherited; if it is, the mode of inheritance needs to be determined. We are currently developing a colony of dogs where the pectineus muscle is examined in puppies and the presence or absence of a lesion noted. This information is being used as a basis of selected matings, and assessing the role of the pectineus muscle in the etiology of canine hip dysplasia.

In conclusion, a developmental myopathy in dogs has been described which has the potential for influencing the development of the hip joint. It is difficult to imagine that this disease which affects the structure and function of the pectineus muscle is merely a myopathy of no clinical significance.

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Table 1. Incidence of developmental myopathy in the pectineus muscle of dogs, 28 to 118 days of age

| Breed or type | Number examined | Normal | Abnormal | Percent affected |
|-----------------|-----------------|--------|----------|------------------|
| German Shepherd | 52 | 13 | 39 | 75 |
| Mongrel | 16 | 13 | 3 | 19 |
| Greyhound | 18 | 18 | 0 | 0 |



Fig. 1. Radiograph of a Greyhound, 6 months old. The acetabula are semicircular with sufficient depth to accomodate the head of the femur which is smooth, rounded and seated well in the acetabulum. The shape and depth of the hip joints are within normal limits.



Fig. 2. Radiograph of a German Shepherd, 18 months of age. The acetabula are shallow and the femoral heads are flat. The hips are dysplastic.

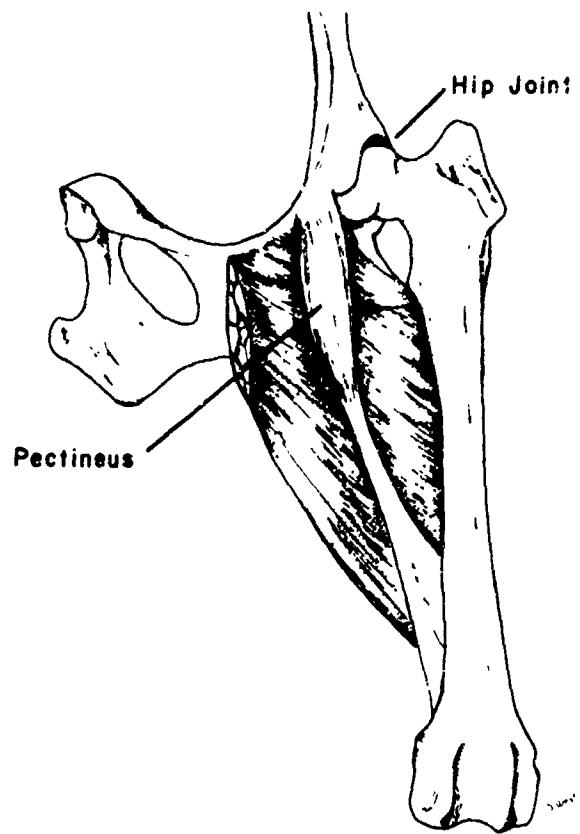
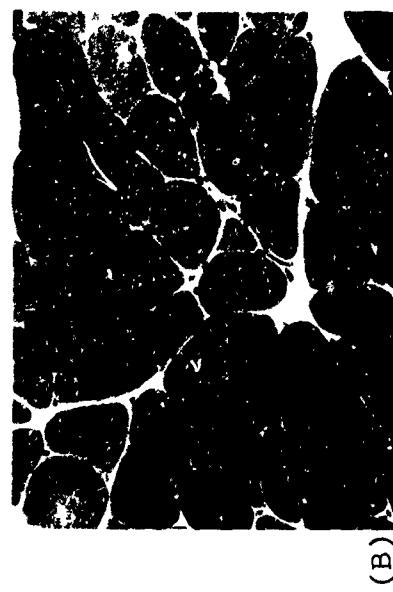


Fig. 3. Diagrammatic representation of the relationships of the pectineus muscle and the hip joint. The pectineus muscle originates from the prepubic tendon and the iliopectineal eminence, and inserts on the medial and posterior aspect of the distal femur. It is innervated by the obturator nerve and weighs approximately 3 grams per 10 kilograms of body weight.



(B)



(A)



(C)

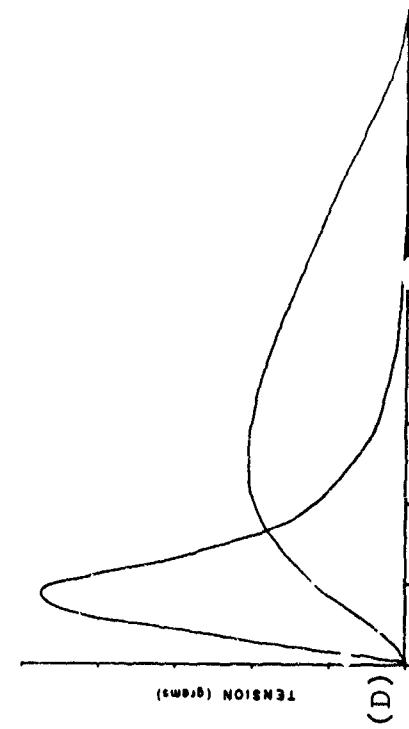


Fig. 4. Serial transverse sections of pectineus muscle incubated for the histochemical demonstration of (A) succinic dehydrogenase, (B) myosin-ATPase and (C) phosphorylase. Type I muscle fibers are characterized by higher activities (dark staining) for succinic dehydrogenase and low activities (light staining) for myosin-ATPase and phosphorylase. Type II fibers are characterized by low activities for succinic dehydrogenase (light staining) and high activities (dark staining) for myosin-ATPase and phosphorylase. Muscles composed primarily of Type II fibers contract faster than muscles composed primarily of Type I muscle fibers (D).

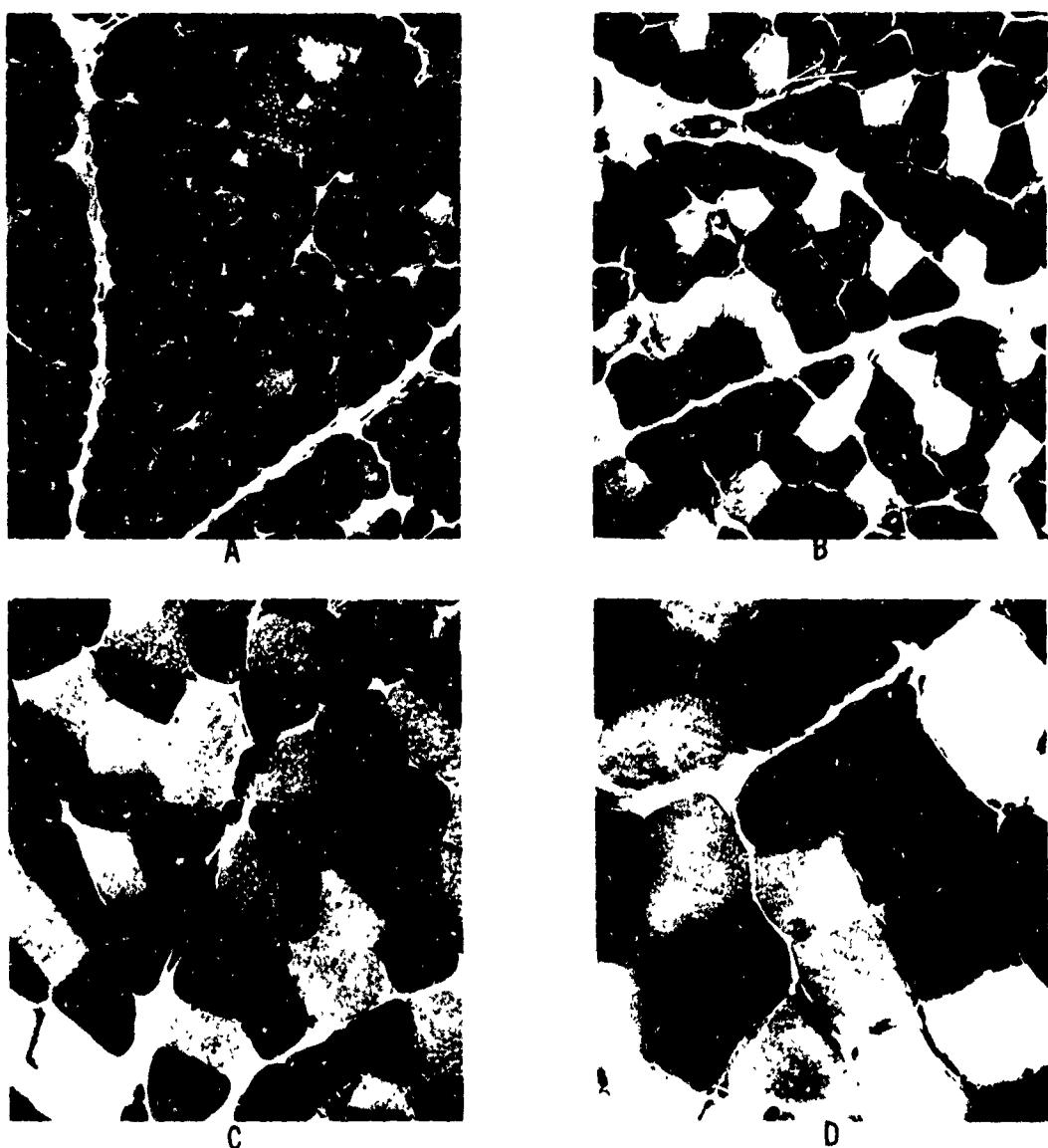


Fig. 5. Transverse sections of normal pectineus muscles stained for myosin-ATPase. Type I fibers are light staining while Type II fibers are dark staining. This series illustrates the growth and differentiation of muscle fibers. (A) At 10 days of age the fibers are small, and the percentage of fiber types is approximately 97% Type II and 3% Type I; (B) at 55 days of age, 63% Type II and 35% Type I; (C) at 118 days, 55% Type II and 45% Type I; and (D) at 267 days, the percentage of each fiber type is approximately 50%. During this same period of time where there is a transformation of Type II fibers to Type I fibers, the fibers increase in size by approximately 30-fold. All photomicrographs are at the same magnification.

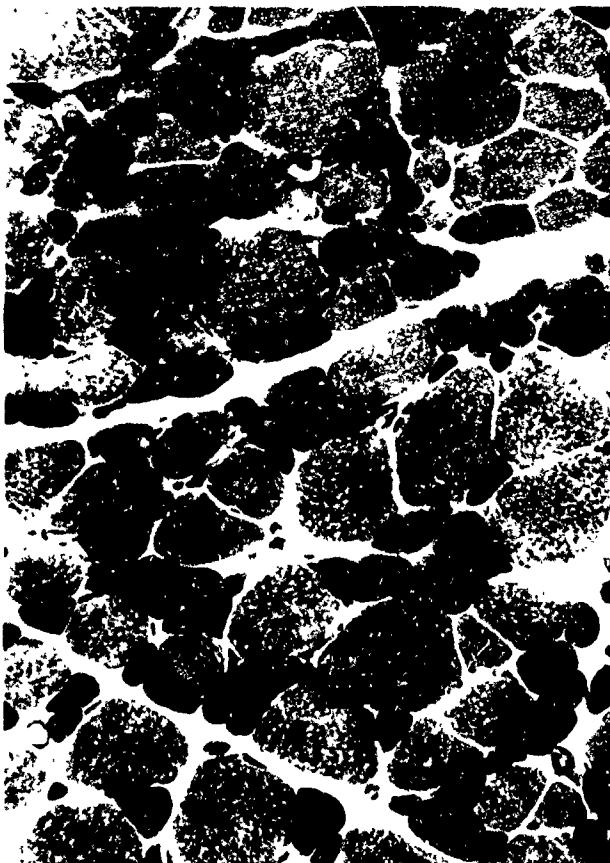
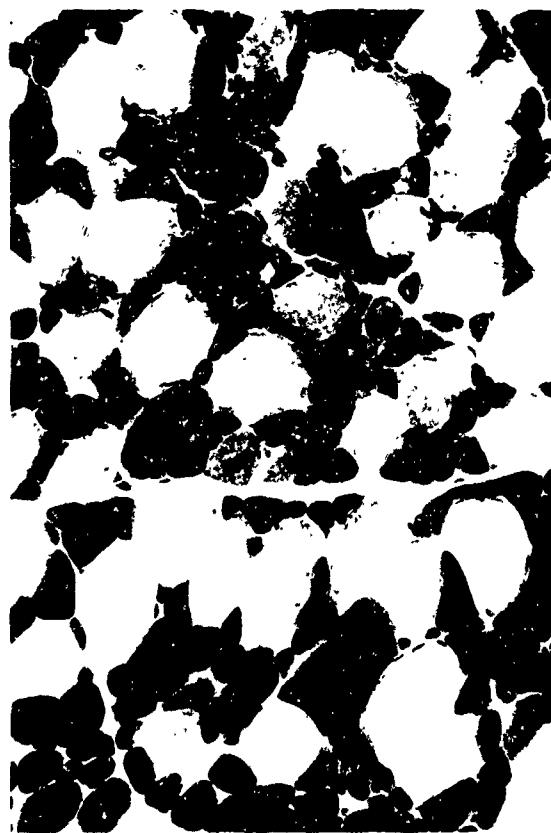


Fig. 6. Pectineus muscle from an abnormal 57 day-old German Shepherd stained for myosin-ATPase (X 400). There is a wide variation in fiber size, with the smaller fibers being predominantly Type II fibers, while the larger fibers are predominantly Type I. This pattern of fiber size variation is typical of the lesions observed.



A



B

Fig. 7. Sections of pectineus muscle from an abnormal 48 day-old German Shepherd stained for myosin-ATPase: (A) unaffected area of the muscle (B) affected area. Magnification is the same for both photomicrographs.

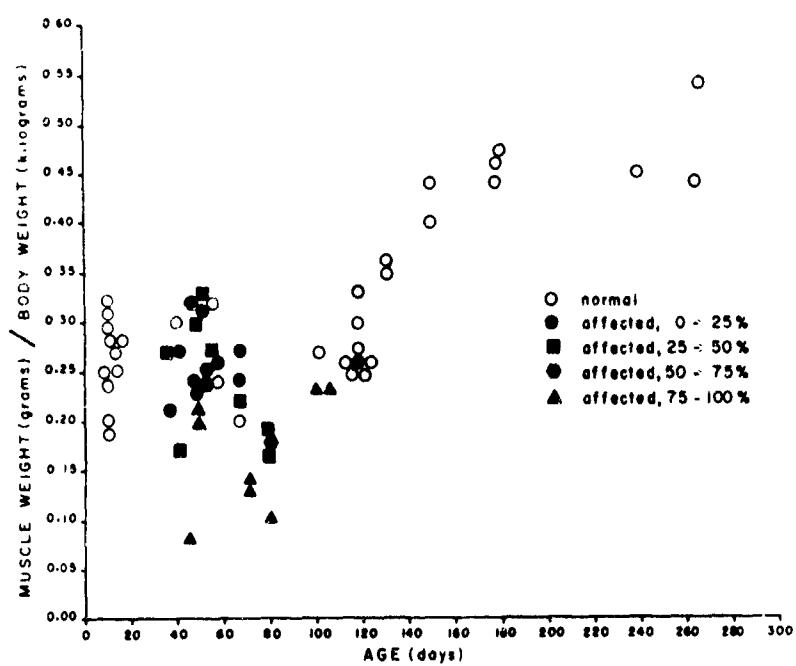


Fig. 8. Comparison of pectineus muscle weights, for normal and abnormal dogs, expressed per unit body weight (grams of muscle per kilogram body weight). The relative weights of normal muscles are identified by open faced figures and abnormal muscles by dark faced figures. In diffusely affected muscles the relative muscle weights were smaller than in the normal muscles.

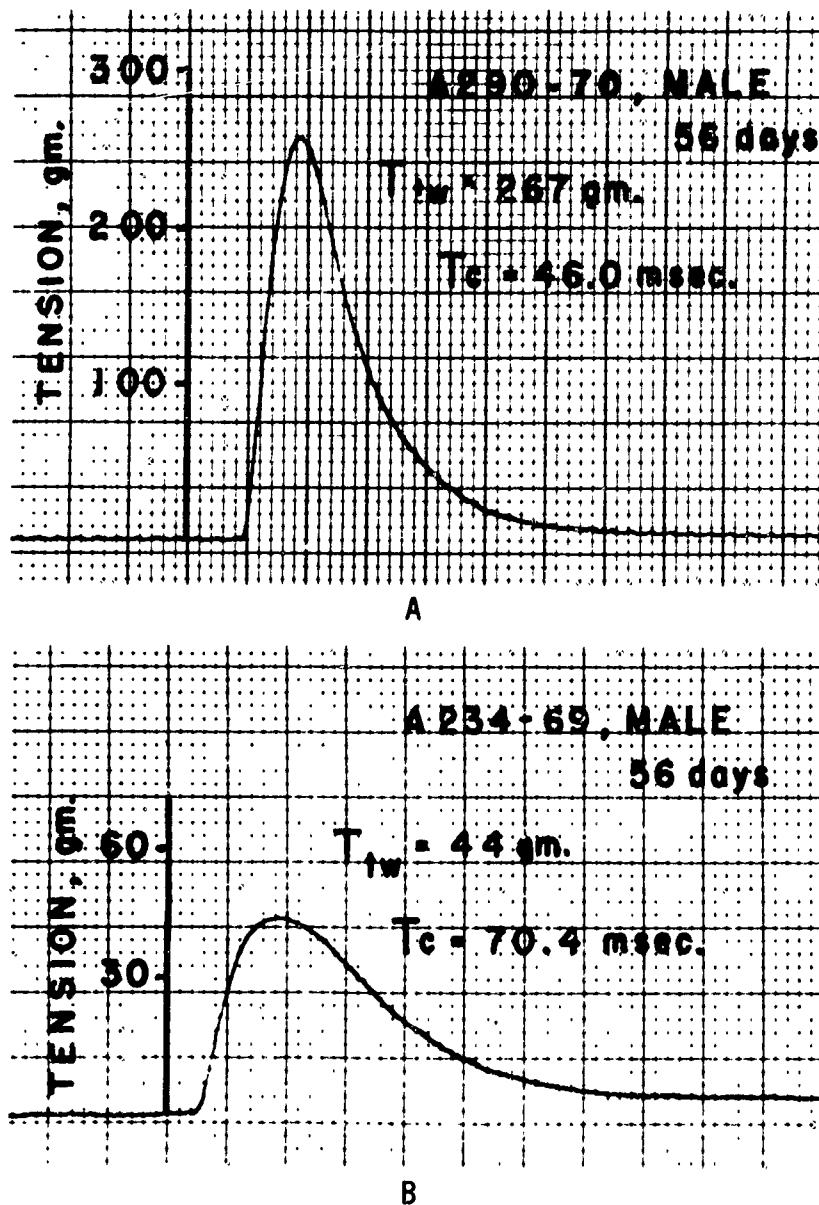


Fig. 9. Tracings of single muscle twitches of pectineus muscles from (A) normal, and (B) abnormal German Shepherd dogs, 56 days of age. The contraction time for the normal muscle was 46.0 milliseconds and developed a maximum tension of 267 grams. By comparison, in the abnormal muscle the speed of contraction was slower (70.4 milliseconds) and it developed a smaller twitch tension (44 grams).

Veterinary Medical Requirements for Olfaction Research
in Support of the Military Working Dog

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Introduction:

Despite the facts that we have a good understanding of the senses of sight, hearing and touch, and that olfactory research has grown considerably in the last decade or two, we still know very little about the basic functional mechanism of the sense of smell. Olfactory theories have been postulated for almost a century, but none have been supported by experimental evidence. As is often true in most biological research, newly acquired facts merely confirm the complexity of the subject which was already suspected. The answer to one question opens the door to several new questions. And this is where we presently find ourselves in olfactory investigations. Small bits of new information are being zealously pried loose adding more pieces to the puzzle. Someday when all these pieces start fitting together, we will be able to begin formulating the steps of odor sensing from detection to interpretation.

In this presentation I will discuss (1) the ultrastructure of olfactory epithelium, (2) some of the research that is being done and, (3) the needs and value of olfactory research that correlate and can contribute to the usefulness of the working military dog.

Ultrastructure of Olfactory Epithelium:

The three types of cells found in olfactory tissue are shown in Figure 1. The function of the basal cell is completely unknown and since it is not in contact with the outside environment and apparently not directly involved with odor detection, it receives little attention.

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Although the bipolar sensing cells outnumber the sustentacular or supporting cells by about 3 to 1 in the adult rabbit, the bipolar cells do not make contact with each other distal to their cell bodies. We do have some evidence however, that they do make contact at their cell body or nuclear level where the supporting cells taper to a narrow diameter. At their distal ends tight junctions are formed between supporting cells and between bipolar and supporting cells. That "chemical communication" could occur between the two types of cells through these junctions is pure conjecture at this time. It must be admitted though that the support implied by the name of the cell is more than physical. The supporting cell, covered by hundreds of microvilli on its exposed end, offers extensive surface area suggestive of an absorptive function. In some animals, however, particularly amphibians, mucus is secreted by these cells. In many mammalian species the mucus is produced by the Bowman's glands peculiar to the underlying lamina propria of olfactory epithelium.

The bipolar cell, being a specialized type of nerve cell, is assumed to be the sensing cell. Its unusual morphology (Fig. 2) makes it an interesting cell type to study. The cells are about 60μ to 100μ in length and only 5μ to 10μ in diameter at the widest part of the cell body. The dendrite narrows to 1μ at the base of the terminal swelling. (The appearance of some of these structures in the electron microscope is shown in Fig. 3). The cilia, 0.5μ in diameter, possess the classical $9 + 2$ internal fiber pattern suggesting a motility rather than sensory function. Mitochondria are often concentrated in the distal portion of the dendrite. Increased numbers of centrioles are found in the dendrites at various ages. The correspondence of centrioles to cell regeneration will be discussed briefly later.

There are slight differences in some of the olfactory cells between certain animal species, but the significance has not been determined. As mentioned previously the frog supporting cells in contrast to those of the mammals contain large drops of mucus. The cat has what appears to be a variation of the supporting cell. In place of microvilli, these infrequent cells terminate

in much larger finger-like processes containing electron dense fibrous strands. The bipolar cells in dogs contain rootlets which extend proximally from the cilia basal bodies. We have not seen these rootlets in any other animals.

Olfactory Research:

Although most of the research studies I will discuss here are present and past programs at the Honeywell Research Center, two other approaches should at least be mentioned. One of these, electrophysiology, is undoubtedly the oldest and most extensively used technique for investigating the sense of smell in animals. Using macro- and microelectrodes, a great variety of responses have been elicited from odor stimulated olfactory tissues. The type of response depends on a number of factors including the placement of the electrodes in the tissue from the exposed surface to the axons, the number and types of cells contacted, the type of stimulant and concentration, the species of animal, etc. More definitive information will probably be derived when recordings are finally obtained from single sensing cells. The small size of these cells makes that extremely difficult. The electrophysiological results will become more meaningful and clear as the biochemistry of the cells is further uncovered.

The other approach which has drawn the attention of organic chemists for many years is the classification of the odorants and the molecular structure of the odor molecules. Although a concerted effort by at least one investigator in the last 20 years resulted in a new theory based on the volatility, size, shape and electronic status of odor molecules, many questions remained unanswered and much more chemical study is still needed.

Our premise at Honeywell was that a fundamental understanding of the odor detection mechanism had to be based on what is happening at the cellular level. We initiated our studies by thoroughly examining the ultrastructure of the various cell types with the electron microscope. While making these observations, we noticed the increased numbers of centrioles in some of the bipolar

cells. Centrioles are known to function in two capacities; cell division and cilia formation. The cells were from adult animals so we wondered if new cilia were being formed, if cells were being partly or completely regenerated or if sensing cell formation continues throughout the life of the animal as do sensing cells in taste buds. Results in the published literature are controversial depending on the animal species and means of cell destruction. Our studies with rabbits show conclusively that within 4 days after differential destruction of the olfactory epithelium with a 1% zinc sulfate solution, new cells are forming. By 8 days partial differentiation is occurring and by 30 days regeneration of the olfactory tissue is essentially complete. Yet to be determined is when and if the bipolar sensing cells become functional. What has not been shown before to our knowledge is that all the new cells come from the Bowman's glands.

Another study evolving from the use of the electron microscope is the combination of it with radioautography in an attempt to locate the exact site of odor molecule detection on the plasma membrane of the sensing cell. This has not been accomplished to date, but we have found the isotope-tagged odor molecules inside the supporting cells in lysosome-like structures. This may be the supporting cell's normal reaction for the post-perception uptake and degradation of odorant molecules.

Our biochemical studies are directed toward determining the initial chemical or physical changes occurring at the molecular level when olfactory tissue is stimulated. The enzyme approach was to isolate subcellular fractions of the cells by grinding them in a tissue grinder followed by differential and sucrose density gradient centrifugation. The 3 fractions of primary interest were the mitochondria, the plasma membranes of terminal swellings from olfactory sensing cells and the plasma membranes of nerve ending particles from brain cells. The two types of cells were used to determine whether the observed membrane reactivities are specific for olfactory tissue or possibly general for nerve cells. The ATPases in both types of tissue showed differences in response to octanol according to the source of the enzymes. The

Mg^{2+} ATPase activity in mitochondria was stimulated whereas the plasma membrane bound Mg^{2+} ATPase was inhibited. A less pronounced but possibly more interesting effect of octanol was the observation that the $Na^{+}-K^{+}$ ATPase from olfactory tissue responded differently from that of brain at low concentrations of the alcohol. The small but significant stimulation of the $Na^{+}-K^{+}$ ATPase activity from olfactory tissue by low concentrations of octanol has led to the speculation that this enzyme may be active early in the sequence of biochemical events occurring in the odor sensing process.

A second biochemical approach takes a look at the mucus which covers the exposed surfaces of the sensing and bipolar cells. A soluble preparation (protein) was isolated from the mucus or cell surface and an absorbance spectra was obtained using ultraviolet difference spectroscopy. An absorbance decrease which was maximum at 267 nm was generated when specific stimulants were mixed with the olfactory preparation. In addition, it was determined that a dialyzable cofactor was also required to cause the absorbance change. This cofactor was found to be ascorbic acid (vitamin C). The results of these studies support the following conclusions. 1. Ascorbic acid is a dialyzable cofactor in the olfactory preparations; it is required for the stimulant induced activity monitored by the absorbance change at 267 nm. 2. In the olfactory preparations the ascorbic acid is bound to proteins and in this bound form it is stabilized against oxidation to the dehydroascorbic acid. 3. Introduction of the stimulant triggers a change in protein conformation which renders the ascorbic acid available for oxidation. 4. The decrease in absorbance monitored at 267 nm is due to oxidation of the "freed" ascorbic acid. 5. Electron microscopy studies of the olfactory epithelium before and after obtaining the olfactory preparations support the hypothesis that in vivo components of the olfactory preparations are associated with the surface of the biological sensors. 6. The stimulant induced conformation change might therefore represent the transduction step in olfaction which alters permeability of the cell membrane and thereby initiates the production of the electrical impulse which is transmitted to the brain for interpretation.

Olfactory Research and the Working Military Dog:

The question that now confronts us is how to use all that has been learned from past research to help in training the working dog? And what additional or new research approaches should be initiated and diligently pursued to find solutions for the many yet unanswered questions concerning the various aspects of the olfactory system? We have been discussing very briefly the fundamental types of research being conducted to understand the mechanism of odor detection, but there are other factors that can have a profound influence on the sense of smell either directly or indirectly. We should not overlook these since knowledge of them, correlated with what is known about the sensing cells themselves, may have an important bearing on the training and/or behavior of the dogs. Some of these added variables that should be considered in a discussion like this are hereditary factors, hormones and drugs, nutrition, and disease.

Heredity Factors:

It has been speculated for years by a number of theorists that there are different types of sensing cells or different kinds of receptor sites on the cells each specific for a particular "class" of odors. This may be actually different from parosmia but is considered as or included in parosmia by some individuals. Admittedly degrees of parosmia could result from injury, disease or anatomical defects, but it is not unreasonable to believe that such conditions could be carried by the genes. If genetics were involved, the possibility exists that either a high sensitivity or an insensitivity to certain odors could be acquired through selective breeding. What is needed first is an accurate technique to measure the exact extent of parosmia. Behavioral approaches are possibly the most feasible, but subjective tests leave much to be desired. An electrophysiological arrangement such as electrode implantation in the olfactory bulbs could ultimately be the method of choice but procedures still need much refinement. With such a complex system as olfaction, the control or change of just one variable may have little effect on the

overall system; possibly parosmia studies should also be considered in conjunction with hormones and drugs, discussed next.

Hormones and Drugs:

Chemicals, including hormones and drugs, have been tested for their effect on olfaction by being applied directly to the olfactory tissue and by injection into the blood stream. The reported results have been extremely varied, due in part to the difficulty in determining where and how the chemicals acted in the body. The hormone studies have been done mainly on primates and humans and in correlation with sexual activities, primarily pregnancy and menstruation. The actual physical condition of nasal epithelium varies, e.g., in swelling and wetness, according to the amount of sex hormones in the blood at that time. These findings may not be applied to dogs except to indicate a possible increase or decrease in olfactory sensitivity by administration of sex hormones. There are many other hormones in the complex neuroendocrine system whose effect on the olfactory system should be investigated.

In Russia some studies done on drugs administered to dogs claim to have shown improved olfactory performance. More studies of this nature could give much needed information, although in the Russian studies it has been questioned if the improvement was not actually caused by motivational factors. This again stresses the value of objective investigations. In humans depression of olfaction following drug injection may also involve motivational factors. In some cases of resulting anosmia due to application of zinc sulfate (as in our rabbit studies) or of certain antibiotics, the effect is undoubtedly caused by destruction of the tissue. Experiments have also been done in which odorant materials have been injected intravenously, intramuscularly or given orally with a variety of results consisting of all combinations of higher thresholds, lower thresholds and no change. It is fairly evident, though, that olfactory sensitivity can be changed by a variety of chemicals administered in a number

of ways. Intensified and carefully directed research aimed specifically at dogs is necessary to collect and correlate the positive findings.

Diseases:

If a correlation exists between the olfactory system and disease, it is not readily evident except possibly in upper respiratory infections. In this aspect it may be important to remember that the olfactory system is the only part of our nervous system which is a direct connection with no synaptic junction between the outside environment and the brain. Some interesting experiments were performed some time ago with experimental poliomyelitis in monkeys. Prior to introducing the virus intranasally, the nasal passage was irrigated with a zinc sulfate solution. That the initial virus infection did not "take" was explained by the fact that the olfactory tissue was destroyed so that the nervous pathway by which the virus could reach the brain was interrupted. Resusceptibility to an inoculation followed 3 or 4 months later when it was assumed that the bipolar cells had regenerated. It seems conceivable that disrupted tissue is more susceptible than is healthy tissue to non-neurotropic viruses and bacteria. If this is true then our findings in the rabbit that olfactory cells are actively regenerating in less than 3 days is important to the animal's ability to fight infection. However, the exposure of this specialized nervous tissue to the outside environment and its short direct path to the central nervous system make it extremely vulnerable as well as causing the involvement of the other nervous systems in the whole animal. Obviously little is known about this possible route of infection. Experiments of this type could be fairly easily set up and controlled.

Nutrition:

This is an area in which some of the answers are fairly obvious. The general health of any animal depends on good nutrition, of course, but studies on the effect of hunger on olfaction have given varied and vague results. Reportedly, a physician has successfully treated parosmic and anosmic conditions with weekly injections of vitamin A. It is truly unfortunate that others have been unsuccessful in using this treatment. Our own biochemical studies with vitamin C as a cofactor in the initial detection step should be extended from this aspect as well.

Summary:

We have looked at the cells involved in odor sensing, at some of the research that has been done, and at some of the research that remains to be done. Because of time limitations or, more accurately, because of the lack of information, I have not even mentioned odor fatigue. This important aspect of odor sensing presents a complete research problem in itself. Hopefully forthcoming answers from other research approaches will contribute to the understanding of fatigue. One point that readily comes to the forefront from a discussion like this is the realization of the small amount of olfactory research that has been done on dogs and how much more should be done. Future research should be highly organized and thoughtfully planned to correlate with other on-going olfactory research programs. Results from this would be invaluable in helping train the military working dog for even greater efficiency.

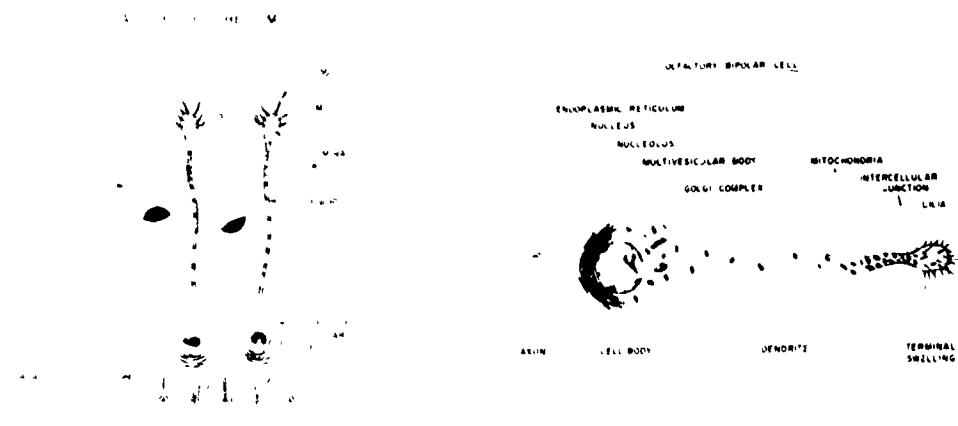


Figure 1

Diagrammatic drawing of the cells in olfactory tissue

Figure 2

Diagrammatic drawing of the details of the odor sensing cell.



Figure 3

Electron photomicrograph of the terminal swelling and cilia of the odor sensing cell.

ATTENDEES AT THE CONFERENCE ON RESEARCH TO EXPAND
THE USEFULNESS OF THE MILITARY WORKING DOG

Wilford Hall USAF Medical Center
Lackland AFB Texas 18-20 March 1970

Dr. Robert Berryman, Manager, DOD Themis Project,
University of Mississippi, University, MS 38677

Capt Robert M. Sullivan, Commander, Det 37, HQ SAAMA,
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Lt Col Logan A. Damewood, DCS Programs, HQ Office
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Dept. of Veterinary Medicine, Medical Service
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ATTENDEES A: THE CONFERENCE ON RESEARCH TO EXPAND THE USEFULNESS OF THE MILITARY WORKING DOG 18-20 March 1970

Dr. Robert Berryman, Univ. of Mississippi
Capt Robert M. Sullivan, Det 37, SAMA
Lt Col Logan Damewood, OAR
Capt Manual Thomas, Medical Service School
Mr R. Andersson, Univ. of Mississippi
Dr. Harvey Savelly, AFOSR
Lt Col Charles E. Fuller, AFOSR
Maj Del Buckholt, Wilford Hall
Mrs. Emily Frazier, Wilford Hall
Capt Donald Ross, Military Dog Center
Maj David C. Van Sickle, Purdue Univ.
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Mr. Bo Hillburn, Mil. Working Dog Program
Maj Russell Barker, Randolph AFB
Maj Roland C. Olson, Wilford Hall
Dr. Carl M. Schulz, Riviana Foods, Inc.
Lt Col James H. McNamara, HQ USAF
Dr. Herbert Heist, Honeywell Corp.
Maj Harold W. Casey, Sch. Aerospace Med.
Col Robert Crandall, Sch. Aerospace Med.
Dr. Mark L. Morris, Jr., Mark Morris Assoc.
Lt Col Paul Holmes, AFIP
Mr. Dan Taylor, AFOSR



Army dog handler holds his dog for footpad check by Maj Roland C. Olson, VC, Chief of the Military Dog Veterinary Services at Lackland. Looking on are Col Harold C. Davis, VC, Command Veterinarian, SAC, and Lt. Col. Charles E. Fuller, VC, of AFOSR (second from left).



Canine pelvic radiograph techniques are reviewed by Air Force veterinarians, from left, Lt. Col. Charles E. Fuller, AFOSR; Maj. Roland C. Olson, Wilford Hall USAF Medical Center; Col. William P. Hayman, Director of Veterinary Services, Wilford Hall USAF Medical Center; and Col. Harold C. Davis, Command Veterinarian, Strategic Air Command.



The Air Force patrol dog may be called upon to work around strangers or to be worked by handlers other than his own. This patrol dog, a retrained sentry dog, demonstrates friendliness with Lt Col Col Farrel R. Robinson, VC, of the Division of Veterinary Pathology, Armed Forces Institute of Pathology.



Midnight, an Air Force marijuana dog, has sniffed out a packet of the drug wrapped in plastic and hidden in the hubcap of an automobile in a parking lot crowded with cars. In a five-minute search, the dog checked 50 or more automobiles to locate the packet, and indicated its presence to the handler, despite the heavy masking odors of gas and oil present in the lot.

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